

## **General Disclaimer**

### **One or more of the Following Statements may affect this Document**

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

# NASA TECHNICAL MEMORANDUM

(NASA-TM-78146) CANDIDATE LOCATIONS FOR SPS  
RECTIFYING ANTENNAS (NASA) 92 p HC A05/MF  
A01 CSCL 10A

N78-13553

Unclas  
55250

G3/44

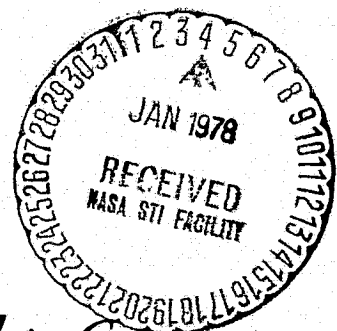
NASA TM-78146

## CANDIDATE LOCATIONS FOR SPS RECTIFYING ANTENNAS

By Anne W. Eberhardt  
Preliminary Design Office

November 1977

NASA



*George C. Marshall Space Flight Center  
Marshall Space Flight Center, Alabama*

|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          |                                                                 |                       |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|-----------------------------------------------------------------|-----------------------|
| 1. REPORT NO.<br>NASA TM - 78146                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | 2. GOVERNMENT ACCESSION NO.                              | 3. RECIPIENT'S CATALOG NO.                                      |                       |
| 4. TITLE AND SUBTITLE<br>Candidate Locations for SPS Rectifying Antennas                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                          | 5. REPORT DATE<br>November 1977                                 |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          | 6. PERFORMING ORGANIZATION CODE                                 |                       |
| 7. AUTHOR(S)<br>Anne W. Eberhardt                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |                                                          | 8. PERFORMING ORGANIZATION REPORT #                             |                       |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br><br>George C. Marshall Space Flight Center<br>Marshall Space Flight Center, Alabama 35812                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |                                                          | 10. WORK UNIT NO.                                               |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          | 11. CONTRACT OR GRANT NO.                                       |                       |
| 12. SPONSORING AGENCY NAME AND ADDRESS<br><br>National Aeronautics and Space Administration<br>Washington, D.C. 20546                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |                                                          | 13. TYPE OF REPORT & PERIOD COVERED<br><br>Technical Memorandum |                       |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                          | 14. SPONSORING AGENCY CODE                                      |                       |
| 15. SUPPLEMENTARY NOTES<br><br>Prepared by Preliminary Design Office, Program Development                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |                                                          |                                                                 |                       |
| 16. ABSTRACT<br><br><p>An investigation is made into the feasibility of placing 120 Satellite Power System (SPS) rectifying antenna (rectenna) sites across the U.S. In the investigation, an initial attempt is made to put two land sites in each state using several land site selection criteria. When only 69 land sites are located, it is decided to put the remaining sites in the sea and sea site selection criteria are identified. An estimated projection of electrical demand distribution for the year 2000 is then used to determine the distribution of these sites along the Pacific, Atlantic, and Gulf Coasts. A future study will also attempt to include the Great Lakes in this distribution.</p> <p>As a result of this study, a methodology for distributing rectenna sites across the country and for fine-tuning exact locations is developed, and recommendations on rectenna design and operations are made. This developed methodology will be used in the reevaluation of the rectenna sites identified in this preliminary study. It is suggested that the design recommendations be considered in future rectenna design studies.</p> |                                                          |                                                                 |                       |
| 17. KEY WORDS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                          | 18. DISTRIBUTION STATEMENT<br><br>Unclassified — Unlimited      |                       |
| 19. SECURITY CLASSIF. (of this report)<br><br>Unclassified                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 20. SECURITY CLASSIF. (of this page)<br><br>Unclassified | 21. NO. OF PAGES<br><br>91                                      | 22. PRICE<br><br>NTIS |

# TABLE OF CONTENTS

|                                        | Page |
|----------------------------------------|------|
| I. INTRODUCTION . . . . .              | 1    |
| II. LAND SURVEYS . . . . .             | 2    |
| A. Selection Criteria . . . . .        | 2    |
| B. Comments on Each Region . . . . .   | 3    |
| C. Summary of Results . . . . .        | 7    |
| III. SEA SURVEYS . . . . .             | 9    |
| A. Selection Criteria . . . . .        | 9    |
| B. Comments on Each Quadrant . . . . . | 9    |
| C. Summary of Results . . . . .        | 11   |
| IV. CONCLUSIONS . . . . .              | 11   |
| V. WORK REMAINING . . . . .            | 12   |
| REFERENCES . . . . .                   | 67   |
| APPENDIX . . . . .                     | 69   |



# LIST OF ILLUSTRATIONS

| Figure | Title                                                                                                                         | Page |
|--------|-------------------------------------------------------------------------------------------------------------------------------|------|
| 1.     | Artist's concept of rectenna site . . . . .                                                                                   | 14   |
| 2.     | Regions of the U.S. . . . .                                                                                                   | 15   |
| 3.     | Correlation between percent of U.S. population in a region<br>and percent of total electric power used in that region . . . . | 16   |
| 4.     | Rectenna locations in the state of Maine . . . . .                                                                            | 17   |
| 5.     | Rectenna locations in the state of New Hampshire . . . . .                                                                    | 18   |
| 6.     | Rectenna location in the state of Vermont . . . . .                                                                           | 19   |
| 7.     | Rectenna locations in the state of New York . . . . .                                                                         | 20   |
| 8.     | Rectenna locations in the state of Pennsylvania . . . . .                                                                     | 21   |
| 9.     | Rectenna locations in the state of Wisconsin . . . . .                                                                        | 22   |
| 10.    | Rectenna locations in the state of Michigan . . . . .                                                                         | 23   |
| 11.    | Rectenna locations in the state of North Dakota . . . . .                                                                     | 24   |
| 12.    | Rectenna locations in the state of South Dakota . . . . .                                                                     | 25   |
| 13.    | Rectenna locations in the state of Minnesota . . . . .                                                                        | 26   |
| 14.    | Rectenna locations in the state of Nebraska . . . . .                                                                         | 27   |
| 15.    | Rectenna location in the state of Iowa . . . . .                                                                              | 28   |
| 16.    | Rectenna locations in the state of Kansas . . . . .                                                                           | 29   |
| 17.    | Rectenna locations in the state of Missouri . . . . .                                                                         | 30   |
| 18.    | Rectenna location in the state of West Virginia . . . . .                                                                     | 31   |

## LIST OF ILLUSTRATIONS (Continued)

| Figure | Title                                                       | Page |
|--------|-------------------------------------------------------------|------|
| 19.    | Rectenna locations in the state of Virginia . . . . .       | 32   |
| 20.    | Rectenna locations in the state of North Carolina . . . . . | 33   |
| 21.    | Rectenna locations in the state of South Carolina . . . . . | 34   |
| 22.    | Rectenna locations in the state of Georgia . . . . .        | 35   |
| 23.    | Rectenna locations in the state of Florida . . . . .        | 36   |
| 24.    | Rectenna locations in the state of Tennessee . . . . .      | 37   |
| 25.    | Rectenna location in the state of Alabama . . . . .         | 38   |
| 26.    | Rectenna locations in the state of Mississippi . . . . .    | 39   |
| 27.    | Rectenna locations in the state of Oklahoma . . . . .       | 40   |
| 28.    | Rectenna locations in the state of Arkansas . . . . .       | 41   |
| 29.    | Rectenna locations in the state of Texas . . . . .          | 42   |
| 30.    | Rectenna locations in the state of Louisiana . . . . .      | 43   |
| 31.    | Rectenna locations in the state of Montana . . . . .        | 44   |
| 32.    | Rectenna locations in the state of Idaho . . . . .          | 45   |
| 33.    | Rectenna locations in the state of Wyoming . . . . .        | 46   |
| 34.    | Rectenna locations in the state of Nevada . . . . .         | 47   |
| 35.    | Rectenna locations in the state of Utah . . . . .           | 48   |
| 36.    | Rectenna locations in the state of Colorado . . . . .       | 49   |
| 37.    | Rectenna locations in the state of Arizona . . . . .        | 50   |

## LIST OF ILLUSTRATIONS (Concluded)

| Figure | Title                                                                                                      | Page |
|--------|------------------------------------------------------------------------------------------------------------|------|
| 38.    | Rectenna locations in the state of New Mexico . . . . .                                                    | 51   |
| 39.    | Rectenna locations in the state of Washington . . . . .                                                    | 52   |
| 40.    | Rectenna locations in the state of Oregon . . . . .                                                        | 53   |
| 41.    | Rectenna locations in the state of California . . . . .                                                    | 54   |
| 42.    | Rectenna distribution through the nine regions of<br>the country . . . . .                                 | 55   |
| 43.    | Rectenna locations overlayed on principal electric<br>facilities in the Northeastern U.S. . . . .          | 56   |
| 44.    | Rectenna locations overlayed on principal electric<br>facilities in the Eastern North Central U.S. . . . . | 57   |
| 45.    | Rectenna locations overlayed on principal electric<br>facilities in the Western North Central U.S. . . . . | 58   |
| 46.    | Rectenna locations overlayed on principal electric<br>facilities in the Pacific Northwestern U.S. . . . .  | 59   |
| 47.    | Rectenna locations overlayed on principal electric<br>facilities in the Southwestern U.S. . . . .          | 60   |
| 48.    | Rectenna locations overlayed on principal electric<br>facilities in the South Central U.S. . . . .         | 61   |
| 49.    | Rectenna locations overlayed on principal electric<br>facilities in the Southeastern U.S. . . . .          | 62   |
| 50.    | Rectenna locations in the state of Massachusetts . . . . .                                                 | 63   |
| 51.    | Rectenna locations in the state of New Jersey . . . . .                                                    | 64   |
| 52.    | Rectenna location in the state of Delaware . . . . .                                                       | 65   |
| 53.    | Rectenna location in the state of Maryland . . . . .                                                       | 66   |

# LIST OF TABLES

| Table | Title                                                                                                                                                          | Page |
|-------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| 1.    | The Number of Land and Sea Rectenna Sites and the Percentage of the National Population, Electrical Use, and Land Area in Each Region of the Country . . . . . | 8    |
| A-1.  | Alphabetical Listing of States Describing Land Rectenna Locations in Each State . . . . .                                                                      | 70   |
| A-2.  | Elevations Characteristics Key . . . . .                                                                                                                       | 77   |
| A-3.  | Land Usage Key . . . . .                                                                                                                                       | 78   |
| A-4.  | Locations of Rectennas in the Pacific . . . . .                                                                                                                | 79   |
| A-5.  | Locations of Rectennas in the North Atlantic . . . . .                                                                                                         | 80   |
| A-6.  | Locations of Rectennas in the South Atlantic . . . . .                                                                                                         | 81   |
| A-7.  | Locations of Rectennas in the Gulf of Mexico . . . . .                                                                                                         | 82   |

## TECHNICAL MEMORANDUM

# CANDIDATE LOCATIONS FOR SPS RECTIFYING ANTENNAS

## I. INTRODUCTION

Due to the continuing search for new, renewable sources of electric energy to power our energy-intensive society, many groups across the country are considering the feasibility of Satellite Power Systems (SPS). Several alternate concepts for the SPS are being suggested, but most concepts involve generating electric energy at a station in geosynchronous Earth orbit and then beaming this energy to Earth in the form of microwaves. A rectifying antenna (rectenna) then collects this energy and rectifies it to dc power. Afterwards, it is converted to 60 cycle ac and enters the U.S. power grid.

For an ambitious SPS program with a buildup rate to 600 GW, 120 rectennas with 5 GW capacity are required [1]. For this analysis, the rectenna site, which contains the actual rectenna and a safety zone, is assumed to be a 15 mile diameter circle. In all cases, this is sufficient to contain the entire elliptical rectenna (which is somewhat longer at higher latitudes) and some safety zone. Figure 1 shows an artist's concept of a rectenna site.

An initial strategy of putting two sites in each state (except Alaska<sup>1</sup>) has been adopted. Notice that this strategy does not take the distribution of national electrical demand into account. However, after identifying 69 land sites, the remaining sites were placed in the oceans taking an estimated projection of demand into account. The following sections identify 120 preliminary rectenna sites. These sites are identified to illustrate the feasibility of locating 120 sites across the United States and are not suggested as actual locations for rectenna placement.

- 
1. No rectennas will be placed in Alaska due to its high latitude and low population. All statistics quoted in this report exclude Alaska.

**ORIGINAL PAGE IS  
OF POOR QUALITY**

## II. LAND SURVEYS

### A. Selection Criteria

Initially, all rectennas were to be located on land. Data indicate the percentage of total electric power used in a region [2] closely correlates to the percentage of the national population in that region [3]. Figure 2 shows a breakout of the nine regions in the U.S. and Figure 3 shows a correlation between electric power use and population in these regions. Further inspection indicates that regions with large percentages of the U.S. population often have little land available for rectenna placement, since 65 percent of the U.S. population lives east of the Mississippi River on 29 percent of the land [4] (and uses 65 percent of the total U.S. electrical power). Thus, rectenna density on land could not correspond to electrical energy usage without major disruptive impacts.

Seventy-one percent of the U.S. land is west of the Mississippi River with only 35 percent of the population occupying it. Thus, there is room for the majority of the 120 rectennas to be placed in the western U.S., especially in the Mountain, Western North Central, and Western South Central states. However, electrical demand in most areas of these regions is small, and the losses associated with power transmission over great distances is generally large enough to make it undesirable to put the majority of the rectennas in these sparsely populated areas.

Therefore, a compromise strategy which approaches uniform rectenna distribution was initiated. Under this strategy an attempt would be made to put two rectenna sites in each state (excepting Alaska) to identify a total of up to 98 sites. Then the remaining 22 or more sites would be located where possible on land or off-shore to achieve a better distribution with respect to demand.

Next, certain criteria had to be identified to quantify the meaning of a good potential land site. These criteria had to take into account such questions as where people live and how the land is used. The following criteria have been identified for site selection:

1. Minimum impact on land intensively used [5] (e.g., cropland, urban areas, etc.).
2. Minimum impact on population [6].
3. Minimum impact on transportation [7, 8, 9].

4. Minimum elevation variations [10].

5. Maximum Federal land use [11].

These criteria are evaluated to differing degrees of accuracy in this preliminary site selection survey due to the use of general reference material. For example, the readily available references in the area of transportation yield a good evaluation of these impacts. Similarly, the reference material on land usages and Federal land locations allows a fairly good evaluation. However, the references on elevation variation and population distributions only give an approximate evaluation of the impacts. Therefore, the following comments on rectenna locations give only average elevation variation ranges, and often these ranges are too broad to have much meaning. These numbers will be refined in the next phase of the study using topographical maps of the areas in which the rectennas are located. Similarly, the preliminary population displacement assessment uses average county population densities. However, since rectennas are usually located in areas of minimum county population density (away from cities and towns), the actual number of persons displaced should be much less than the estimate given. Better estimates of these displacements will be determined in the next phase of the study using actual county population distributions from state census data books.

## B. Comments on Each Region

The following discussion is broken into nine parts based on the nine U.S. geographic regions identified in the Statistical Abstract of the United States (Fig. 2). Regional data along with statistics on the rectenna land sites are given in each part.

The Northeast region of the country includes Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, and Connecticut. These states contain 6 percent of the U.S. population on 2 percent of the land. Furthermore, 80 percent of the region's population is concentrated in the tiny states of Massachusetts, Rhode Island, and Connecticut; consequently, no land rectennas could be located in these states, but there is potential for sea sites off their coastlines. The remaining states are fairly mountainous, but one rectenna site is identified in the state of Vermont and two each in the states of Maine and New Hampshire. However, one New Hampshire site covers two small towns. These five rectennas displace a maximum of 0.2 percent of the Northeast region's population or 27 000 persons and average 40 miles to an existing power tie. The average elevation range in the area covered by rectennas is 800 to 2200 ft with

ORIGINAL PAGE IS  
OF POOR QUALITY

a maximum of 3000 ft in New Hampshire and Vermont. Approximately 10 miles of road are covered by each site and the predominant type of land impacted is ungrazed forest land. Figures 4, 5, and 6 show rectenna locations in these states with respect to Standard Metropolitan Statistical Areas (SMSA) and county boundaries.

The Middle Atlantic states are New York, Pennsylvania, and New Jersey, which contain 18 percent of the U.S. population on only 3 percent of the land. These data indicate a need for many sites on little land, but there is again the possibility for sea sites. No rectenna sites could be identified in the mostly urban state of New Jersey, but two sites are identified in the densely populated state of New York. Two sites are also identified in Pennsylvania, but one site covers two small towns. These four rectennas displace a maximum of 0.1 percent of the region population or 48 000 persons and average 10 miles to an existing power tie. All of the sites are in mountainous areas and the average elevation range of the impacted areas is 700 to 1800 ft with a maximum of 3000 ft. An average of 10 miles of road is covered by each site, and the only type of land impacted is ungrazed forest land. Figures 7 and 8 show rectenna locations in these states.

Wisconsin, Illinois, Michigan, Indiana, and Ohio form the Eastern North Central region with 19 percent of the national population on 8 percent of the land. These states are densely populated and criss-crossed with many major highways so only four land sites are identified; however, there may be potential for water sites in the Great Lakes. Of the four sites selected, two are located in north Wisconsin, one is located in the northern peninsula of Michigan, and the other is located on the main part of Michigan. These four sites displace a maximum of 0.1 percent of the population or 21 000 persons and average 20 miles to the nearest power tie. The average elevation at each site is 200 to 500 ft with an absolute maximum of 1000 ft. An average of 20 miles of road is covered by each site, and the covered land is predominantly ungrazed forest land with some cropland and pasture. Figures 9 and 10 show rectenna locations in these states.

The Western North Central region includes North Dakota, South Dakota, Minnesota, Nebraska, Iowa, Kansas, and Missouri. They contribute only 8 percent of the national population on 17 percent of the land and contain 13 rectenna sites. Only one site is identified in Iowa due to its density of small towns and major highways, and the two sites identified in Missouri are questionable because they cover small towns. However, the one missing site and the two questionable sites could be placed in more sparsely populated areas of this relatively flat region. The 13 presently identified rectennas displace a maximum of 0.3 percent of the population or 46 000 persons and average 35 miles to a



power tie. The average elevation range at these sites is 100 to 300 ft with a maximum of 500 ft. The average road coverage is 25 miles, and land at the sites is mainly used for crops with some grazing, marsh, grass, and forest land. Figures 11 through 17 show rectenna locations in these states.

The South Atlantic states are Delaware, Maryland, West Virginia, Virginia, North Carolina, South Carolina, Georgia, and Florida. They contain 16 percent of the U.S. population on 9 percent of the land and are quite densely populated. However, these states have excellent possibility for off-shore rectenna placement, and even some of the identified land sites may be moved off-shore. No rectennas could be located in the tiny states of Delaware and Maryland, but two locations are identified in North Carolina (one covers 15 miles of a U.S. highway) and two are identified in Florida. The other South Atlantic states each contain only one rectenna site due to population and transportation constraints, and the Virginia site covers two small towns. The eight rectenna sites identified displace a maximum of 0.2 percent of the region's population or 70 000 persons and average 25 miles to the nearest existing power tie. The average elevation at these sites is 150 to 500 ft, but these averages would be lower if the site in West Virginia, which has an elevation variation of 1000 to 3000 ft, was not included. Each rectenna covers an average of 20 miles of road and the majority of impacted land is marsh and forest with some cropland and grazing land. Figures 18 through 23 show rectenna locations in these states.

Kentucky, Tennessee, Alabama, and Mississippi comprise the Eastern South Central states and contain 6 percent of the U.S. population on 6 percent of the land. Two rectennas are placed in Mississippi and two in Tennessee, but one of the Tennessee sites covers three small towns. The density of small towns and transportation networks allowed only one site in Alabama, and none in Kentucky. Thus, the region contains only five rectennas, but there is some potential for sea sites. These five sites displace a maximum of 0.4 percent of the population or 54 000 persons and average 10 miles to a power tie. The average elevation variation is 300 to 700 ft, and one site in Tennessee has a maximum elevation change of 3000 ft. Each rectenna covers an average of 25 miles of road and the type of land impacted includes forest, grazing land, and cropland with some marsh. Figures 24, 25, and 26 show rectenna locations in these states.

The Western South Central states are Oklahoma, Arkansas, Texas, and Louisiana. These states contain 10 percent of the population on 15 percent of the land, which indicates that the region has some sparsely populated areas. Two sites are identified in each state with a maximum of 0.2 percent of the population or 34 000 persons displaced, but the two sites in Arkansas are

ORIGINAL PAGE IS  
OF POOR QUALITY

questionable because they each cover small towns. However, alternate sites could probably be identified in this region with further analysis. The eight identified rectennas average 25 miles to a power tie, and the average elevation change is 200 to 500 ft with a maximum of 3000 ft at the Arkansas sites. Therefore, if the Arkansas sites were changed, both the population impact and elevation variation statistics would improve. Approximately 15 miles of road are covered by each site, and the predominant type of land under the rectennas is grazing land with cropland, forest, and swamp. Figures 27 through 30 show rectenna locations in these states.

The Mountain states include Montana, Idaho, Wyoming, Nevada, Utah, Colorado, Arizona, and New Mexico. They contain only 4 percent of the U.S. population on 29 percent of the land and form the most sparsely populated region in the country. Although the extremely mountainous areas of the region must be avoided, there is little problem in placing 2 rectennas in each state which means that there are more land rectennas in the Mountain states than in any other region. These 16 rectennas displace a maximum of 0.6 percent of the region's population or 60 000 persons and average 40 miles to a power tie. The average elevation change at the sites is 400 to 950 ft with a maximum height of 3000 ft at the Arizona and Nevada sites. An average of 5 miles of road is covered by each rectenna and the land types covered are grazing land, desert, and grass lands with some cropland and forest. Figures 31 through 38 show rectenna locations in these states.

For this analysis, the Pacific states include only Washington, Oregon, and California. (No rectenna sites are identified in Alaska or Hawaii.) These states contribute 13 percent of the national population on 11 percent of the land. Two rectennas could be identified in each state displacing a maximum of 0.2 percent of the regional population or 47 000 persons, but one Washington site covers a small town. These rectennas average 15 miles to the nearest existing power tie and the average elevation change is 550 to 1250 ft with a maximum elevation change of 3000 ft. Approximately 15 miles of road are covered by each rectenna and the main types of land impacted are desert and grazing land with some forest, cropland, and grass land. Figures 39, 40, and 41 show rectenna locations in these states.

More specific descriptions of rectenna sites in each state can be found in the appendix, Table A-1. This table lists the states in alphabetical order and gives the following rectenna information:

1. Candidate rectenna site location number (e.g., in Alabama locations 1 and 2 were rejected and location 3 accepted).

2. Name of counties impacted.
3. Average population density of each county.
4. Elevation characteristics and land use at each rectenna site.
5. Road, railroad, and river impacts.
6. Distance from each rectenna to a utility tie.
7. Pertinent comments.

Elevation characteristics [10] and land use [5] keys (Tables A-2 and A-3) are given in the appendix. Figure 42 shows an overview of the distribution of the 120 rectennas through the 9 regions of the country, and statistics on the number of land rectenna sites in each region and the percent of the national population, electrical use, and land area in that region are given in Table 1.

### C. Summary of Results

The preliminary population density survey yields an overly pessimistic population displacement profile due to the use of average county population densities. However, even using these averages, only 0.19 percent of the population of the U.S. or 407 000 persons would be displaced by the 69 land rectennas.

The national power grid survey yields an average distance of 30 miles from the rectenna to an existing major power network tie. This result is illustrated in Figures 43 through 49 where rectenna locations are overlaid on charts of the national power grid [12].

The preliminary elevation characteristics survey indicates that elevation variations of at least 1000 ft and possibly up to 3000 ft can be expected. As previously stated, more work must be done to avoid these large elevation variations where possible and to quantify more precisely those variations which still exist.

The transportation analysis shows that the average rectenna covers 16 miles of secondary roads (with one exception where a primary road is covered) and no major rivers or railroads. This indicates that rectenna impact on existing ground transportation networks is minimal. (However, if the microwave beam interferes with air traffic, the impact on air transportation is substantial.)

TABLE 1. THE NUMBER OF LAND AND SEA RECTENNA SITES AND THE PERCENTAGE OF THE NATIONAL POPULATION, ELECTRICAL USE, AND LAND AREA IN EACH REGION OF THE COUNTRY.

| Region             | Number of Land Rectennas | Number of Sea Rectennas | Percentage of National Population | Percentage of National Electrical Use | Percentage of National Land Area |
|--------------------|--------------------------|-------------------------|-----------------------------------|---------------------------------------|----------------------------------|
| Northeast          | 5                        | 6                       | 5.75                              | 4.12                                  | 3.40                             |
| Middle Atlantic    | 4                        | 4                       | 17.63                             | 13.63                                 | 3.40                             |
| East North Central | 4                        | 0                       | 19.33                             | 20.26                                 | 8.22                             |
| West North Central | 13                       | 0                       | 7.89                              | 6.58                                  | 17.11                            |
| South Atlantic     | 8                        | 18                      | 15.71                             | 17.04                                 | 9.22                             |
| East South Central | 5                        | 1                       | 6.33                              | 9.98                                  | 6.02                             |
| West South Central | 8                        | 9                       | 9.74                              | 9.45                                  | 14.52                            |
| Mountain           | 16                       | 0                       | 4.45                              | 5.00                                  | 28.58                            |
| Pacific            | 6                        | 13                      | 13.17                             | 13.94                                 | 10.72                            |

The land use analysis shows a major use of forested land along with a significant use of crop, desert, marsh, and grazing lands. It also shows that 22 percent of the 69 rectennas are at least partially on Federal land.

### III. SEA SURVEYS

#### A. Selection Criteria

Based on 1976 population distribution [3] and 1974 electrical demand distribution data [2], all remaining rectennas should be placed east of the Mississippi River. However, the steady westward and southward shift in the center of population (125 miles west and 40 miles south in the period from 1940 to 1970 [13]) indicates a need for reevaluation. If these data are extrapolated to the year 2000, the center of population will be at approximately  $92^{\circ}$  W longitude and  $38^{\circ}$  N latitude or 40 miles south of Jefferson City, Missouri. Assuming that electrical energy demand is indeed proportional to population distribution (Fig. 3) and denoting the future center of population as the origin of a coordinate system, then 15 more rectennas are required in the Northeast quadrant and 16 more in the Southeast quadrant. Also, four more are required in the Northwest and 16 more in the Southwest quadrants.

This information does not indicate where the population will aggregate in these quadrants, but data over the years from 1940 to 1973 [14] indicate that approximately 50 percent of the U.S. population has consistently lived within 50 miles of a coastline — either the Atlantic Ocean, Gulf of Mexico, Great Lakes, or Pacific Ocean. Because of this and the fact that the off-shore platform industry is continually making advancements which will be directly applicable to rectenna design, an attempt was made to put the remaining rectennas in the sea. The selection criteria for the sea sitings include minimization of rectenna impact on shipping channels and minimization of water depth impact on rectenna design [15].

#### B. Comments on Each Quadrant

As stated earlier, no rectennas will be located off the coast of Alaska. However, electrical demand in the state of Hawaii could reach a point where rectenna placement there would be desirable. A survey of the Hawaiian coastline, however, indicates that only a floating rectenna would be practical there due to the extreme water depth even right off of the shorelines. Because of this, no sites are identified in Hawaii.

A similar problem exists on the west coast of the continental U.S. The sea depths there increase at the lower latitudes making rectenna placement difficult. However, 10 sites are identified north of the 38° latitude axis (which is just north of San Francisco) with a maximum depth coverage of 400 ft. Only 3 sites could be identified south of this line with a maximum depth coverage of 550 ft. These sites account for 13 of the 20 sites desired in the western states. The remaining 7 sites are located in the western Gulf of Mexico with a maximum depth coverage of 125 ft. Figures 39, 40, and 41 show sea rectenna locations in the Pacific Ocean and Figures 29 and 30 show Gulf of Mexico locations.

As stated earlier, 31 additional sites are desired east of 92°W longitude and 15 of these should be in the northeast quadrant. It is believed that of these at least 8 should be located in the Great Lakes for access by the heavily populated East North Central states. However, limited resources require that the identification of Great Lakes sites be postponed until the next phase of this study. To compensate for the possibility that no sites can be identified in the Great Lakes, locations for all 31 eastern sites have been identified in the Atlantic and eastern Gulf of Mexico. This is possible partly because the coastal depths of the Atlantic are considerably less severe than in the Pacific. However, ocean depths increase at higher latitudes and the 6 rectenna sites identified off the coasts of Massachusetts and Maine cover depths to 300 ft. The maximum depth of the 6 sites from New York through Maryland is 130 ft, and the maximum depth of the 11 sites from Virginia through Georgia is only 100 ft. No rectennas are located on the Atlantic coast of Florida to avoid impact on the rectennas by the space program launch activity from Cape Canaveral required to support the SPS program. But, even without this consideration, the Florida rectennas would be placed in the Gulf because it offers a calmer environment for rectenna placement. Therefore, 9 rectennas are located in the eastern Gulf (east of 92°W) with a maximum depth coverage of 138 ft. Figures 4, 7, 19, 20, 21, 22, 50, 51, 52, and 53 show rectenna locations in the Atlantic Ocean and Figures 23, 26, and 30 show rectenna locations in the eastern Gulf of Mexico.

More specific descriptions of rectenna sites off the coast of each state can be found in the appendix in Tables A-4 through A-7. These tables give the sea site location number, coordinates in longitude and latitude, and ocean floor depth ranges. An overall view of sea sites can also be found in Figure 42, and regional statistics on these sites can be found in Table 1.

## C. Summary of Results

In summary, no major shipping channels are impacted by rectenna placement. Even minor impacts could be reduced in some cases if further investigation shows that rectennas could be moved to areas labeled "danger zone," "dumping grounds," [15] etc., or are used to cover groups of hazards since such areas are already avoided by mariners. However, sea depth impacts on rectenna sites may require the use of floating rectennas or the relocation of some sites.

## IV. CONCLUSIONS

Both land and sea sites have advantages and disadvantages. One advantage on the land is the ease of power transmission from a land rectenna into the national power grid (Figs. 43 through 49). Also, land rectennas may encounter less rust and collision problems than sea rectennas. Furthermore, the slight temperature increase under the rectenna could provide longer growing seasons for any crops planted there. Some disadvantages to land sites include the facts that they force people (although relatively few) to give up their homes and property and may require the costly rerouting of roads. In addition, land sites often must deal with greater elevation (depth) changes than sea sites and could be damaged by hurricanes, earthquakes, tornadoes, floods, etc.

Sea sites have many advantages and may even produce benefits. Sea rectennas could aid mariners by providing navigation assistance and by covering submerged hazards. They could be beneficial to fishermen by providing artificial reefs where fish could live and breed in water slightly warmer than the surrounding sea. Also, sea rectennas do not affect private property or require the building of new roads. However, the effects of saltwater, hurricanes, rough seas, ships in a fog, seaquakes, etc., could provide a more hostile environment for rectennas in the sea than on land.

Many of the problems mentioned can be circumvented through planning and design. The land site selection criteria already attempts to minimize population, intensive land use, and transportation impacts along with elevation variations. Future work will use topographical maps and census data on actual population distribution in counties to fine-tune locations. Furthermore, rectenna design and operations schemes can help to minimize problems. For example, rectennas should be designed to avoid the clear cutting of land, and a rectenna

ORIGINAL PAGE IS  
OF POOR QUALITY

operations scheme should be developed to allow intermittent periods of nonpower site activity such as the harvesting of trees, crops, and fish. During these periods the microwave antenna may be switched to an alternate rectenna built for this purpose or turned off for scheduled maintenance. Rectenna design will also have to deal with bad weather and large elevation variations. However, these elevation variations could possibly be taken advantage of to orient the rectenna perpendicular to the beam and thus reduce the site area.

A similar situation is encountered in sea settings. Planning can reduce the number of collisions of ships with rectennas by placing rectennas away from shipping lanes. Extremely tall platforms can be avoided either by careful placement or the design of floating rectennas (an option not available to land sites). Other areas of concern such as power transmission, rust, and weather must be handled by rectenna design.

Planning must also include a careful mix of land and sea locations. It is evident that electrical energy demand in the Western States will increase at a high rate and will probably be concentrated near the Pacific coast. However, the extreme ocean depths encountered in the Pacific, if not handled by floating rectennas, may require the movement of some sea rectenna sites to sparsely populated areas of the Mountain, Western North Central, and Western South Central States. The Eastern States, however, will continue to be densely populated, and the electrical demand there will remain high. This could indicate the need for moving even more rectenna sites from this intensively used land into the shallow waters of the Atlantic Ocean, Gulf of Mexico, and, possibly, the Great Lakes. Thus, if rectenna placement is to correspond to electrical energy demand and if an ambitious SPS program such as described earlier is pursued, both land and sea rectenna sites will be required, and rectenna design studies should proceed accordingly.

## V. WORK REMAINING

In the next phase of the rectenna location study, several improvements will be made to the present distribution and locations of the 120 rectennas. First, a section-by-section electrical demand projection for the year 2000 must be used to reevaluate the distribution of the rectennas. Most locations will probably remain unchanged by this exercise, but some off-shore sites may be moved inland and some inland sites may be moved off-shore. Also, some sites may be moved into the Great Lakes if the study indicates that this is feasible. After the redistribution is completed, new and old sites will be scrutinized.



The new sites will first be evaluated according to the criteria outlined in this preliminary study. All land sites will then be refined in the area or population impact using county population distribution data and in the area of elevation variation using topographic maps.

In general, a fine-tuning of present results should yield a good distribution of land and sea sites. These refined sites should ensure that electrical power will be available where needed and with only minimal impact on land and sea usage.

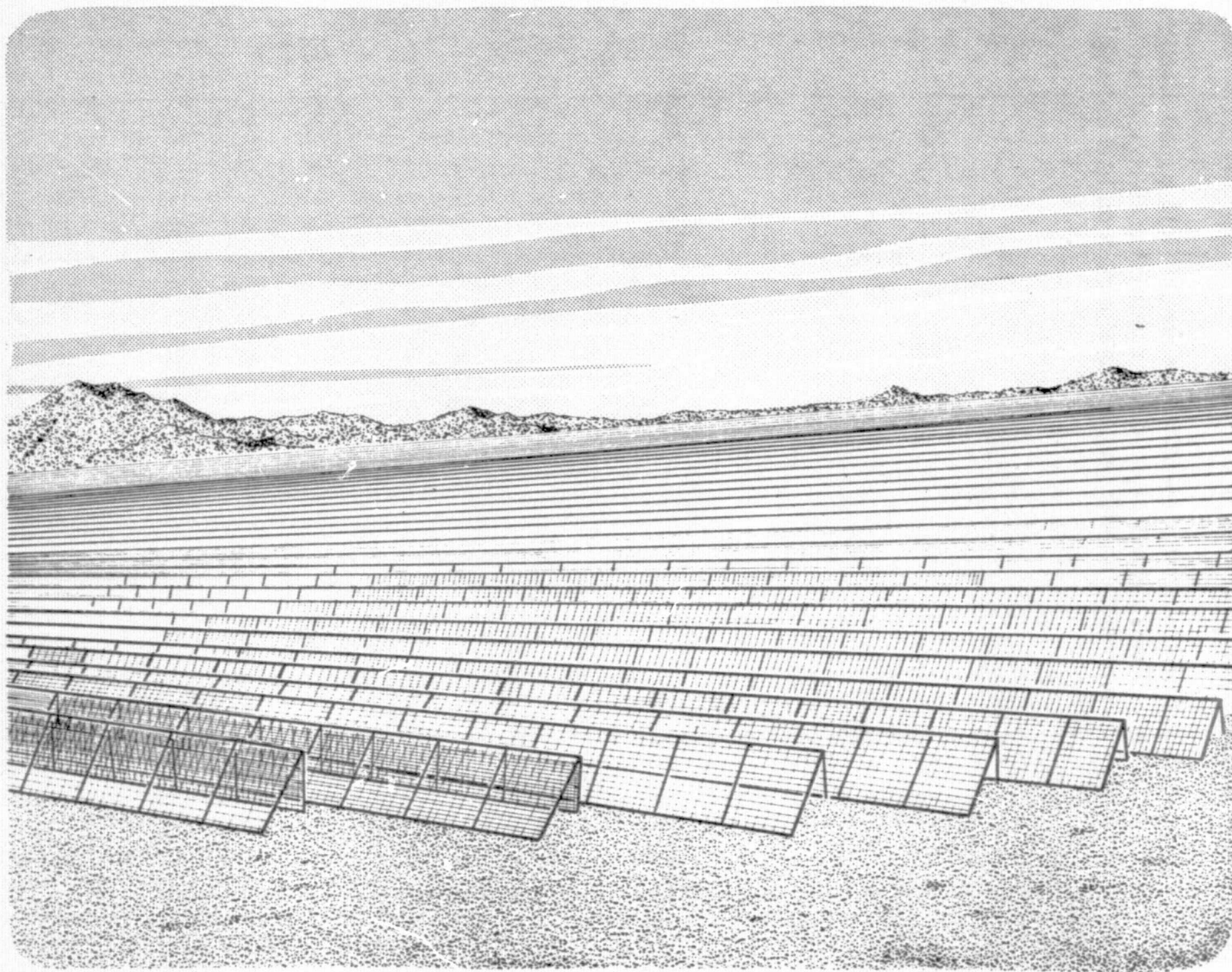


Figure 1. Artist's concept of rectenna site.



Figure 2. Regions of the U.S.

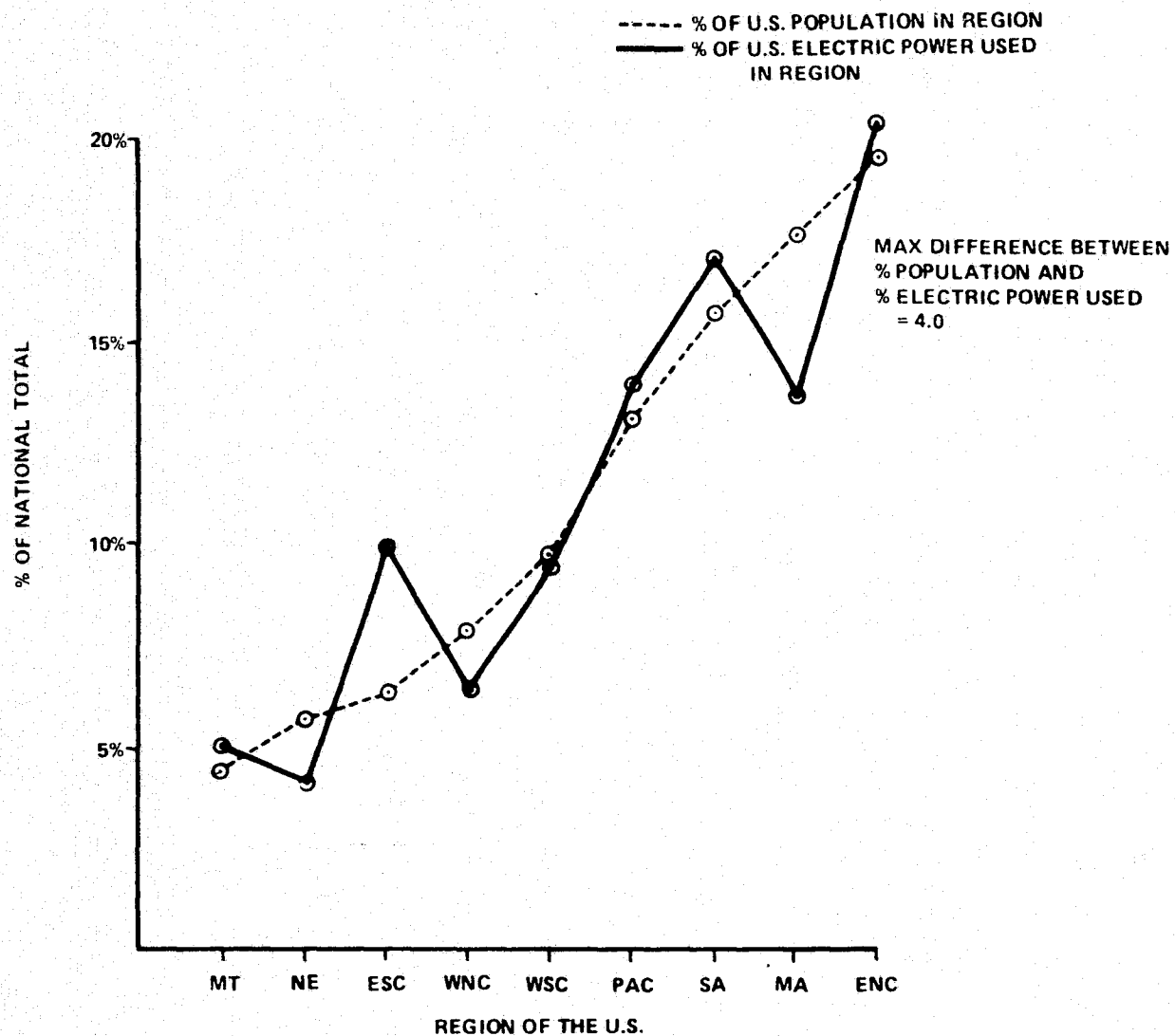


Figure 3. Correlation between percent of U.S. population in a region and percent of total electric power used in that region.

ORIGINAL PAGE IS  
OF POOR QUALITY

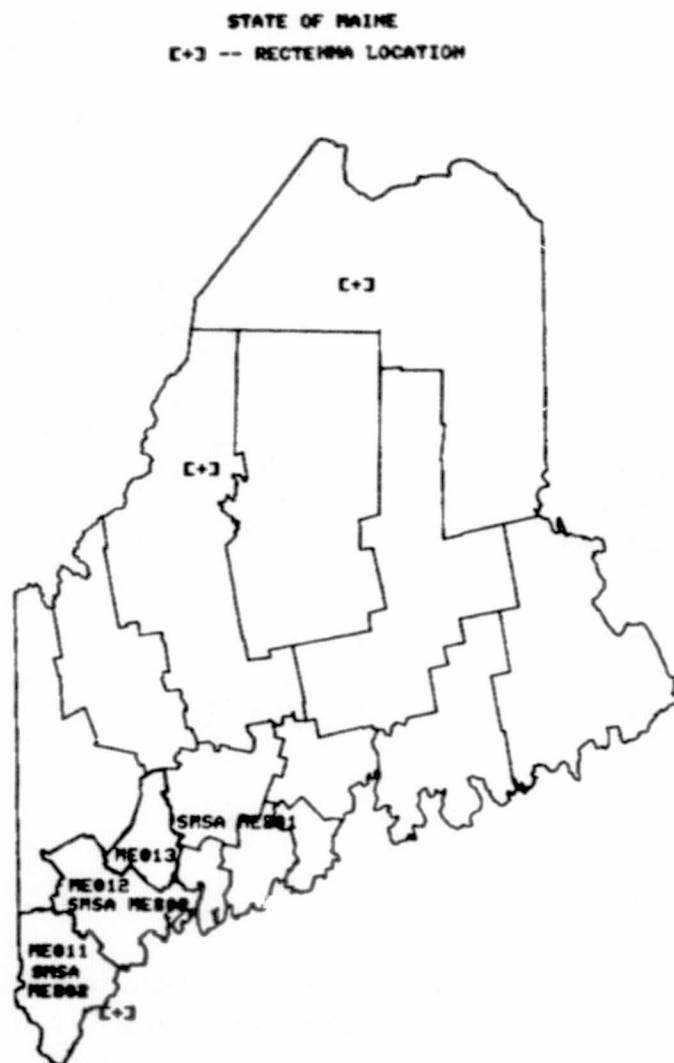


Figure 4. Rectenna locations in the state of Maine.

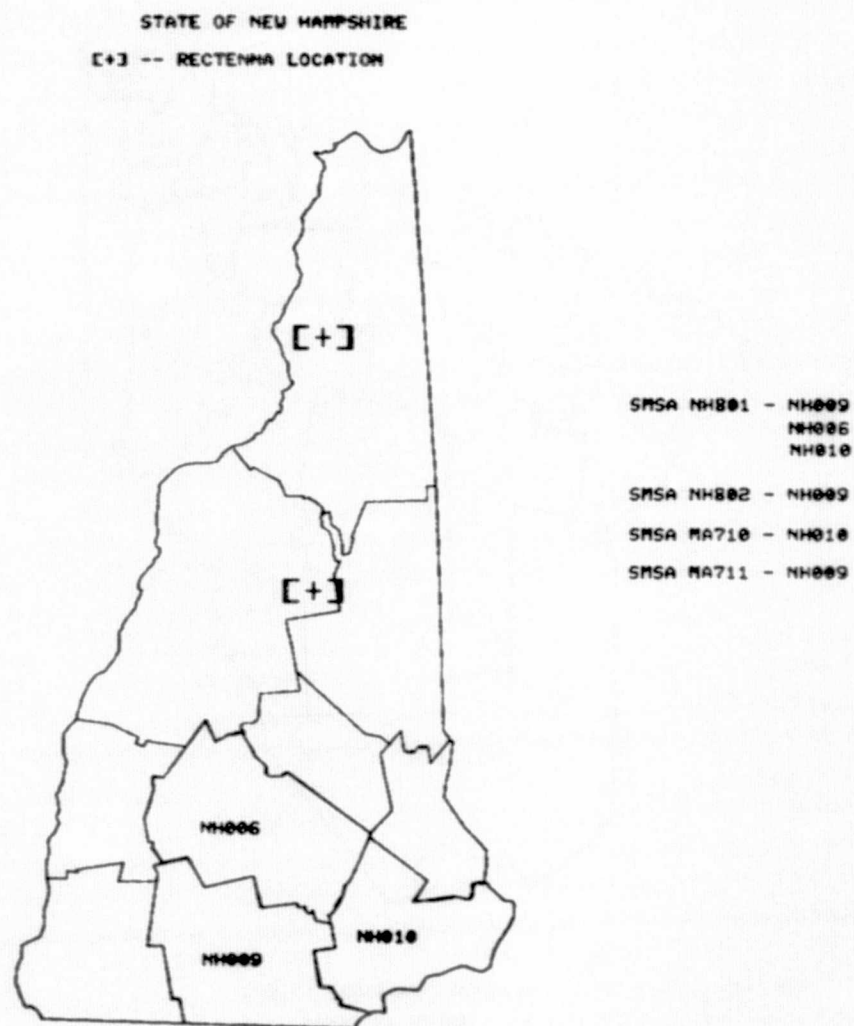


Figure 5. Rectenna locations in the state of New Hampshire.

ORIGINAL PAGE IS  
OF POOR QUALITY



Figure 6. Rectenna location in the state of Vermont.

STATE OF NEW YORK  
[+3] -- RECTENNA LOCATION

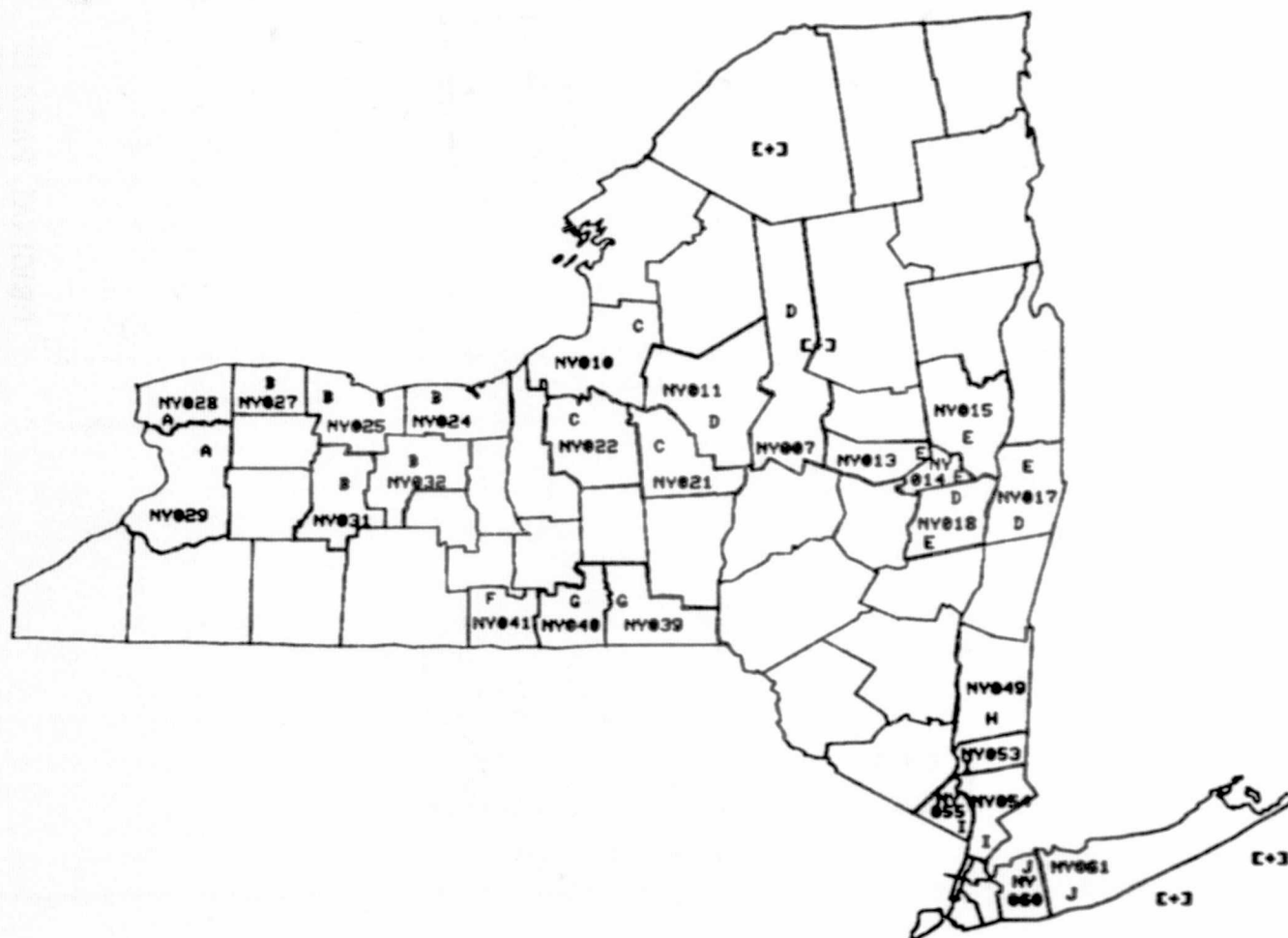


Figure 7. Rectenna locations in the state of New York.



STATE OF PENNSYLVANIA

[+] -- RECTENNA LOCATION

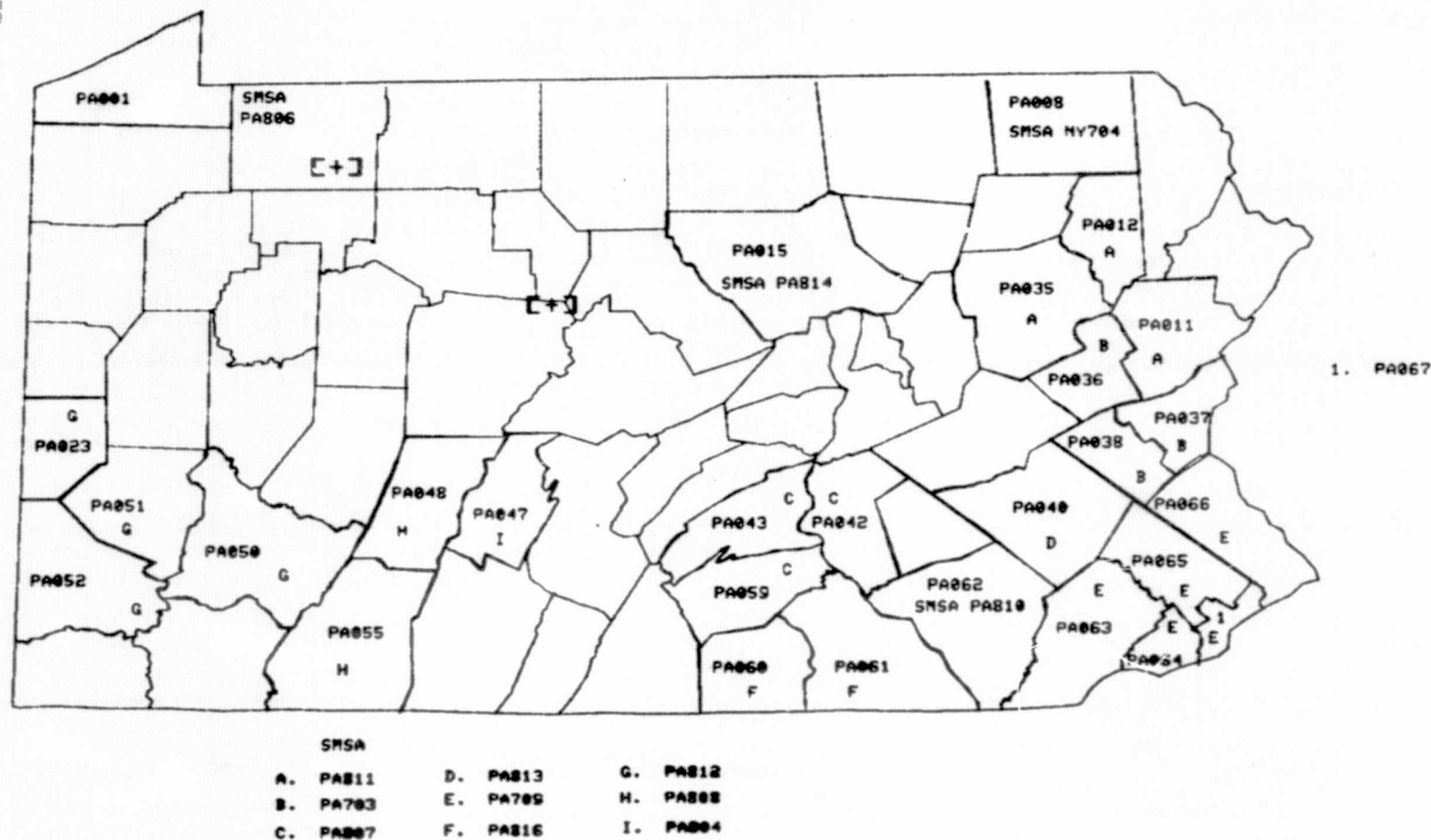


Figure 8. Rectenna locations in the state of Pennsylvania.

## STATE OF WISCONSIN

[+] -- RECTENNA LOCATION

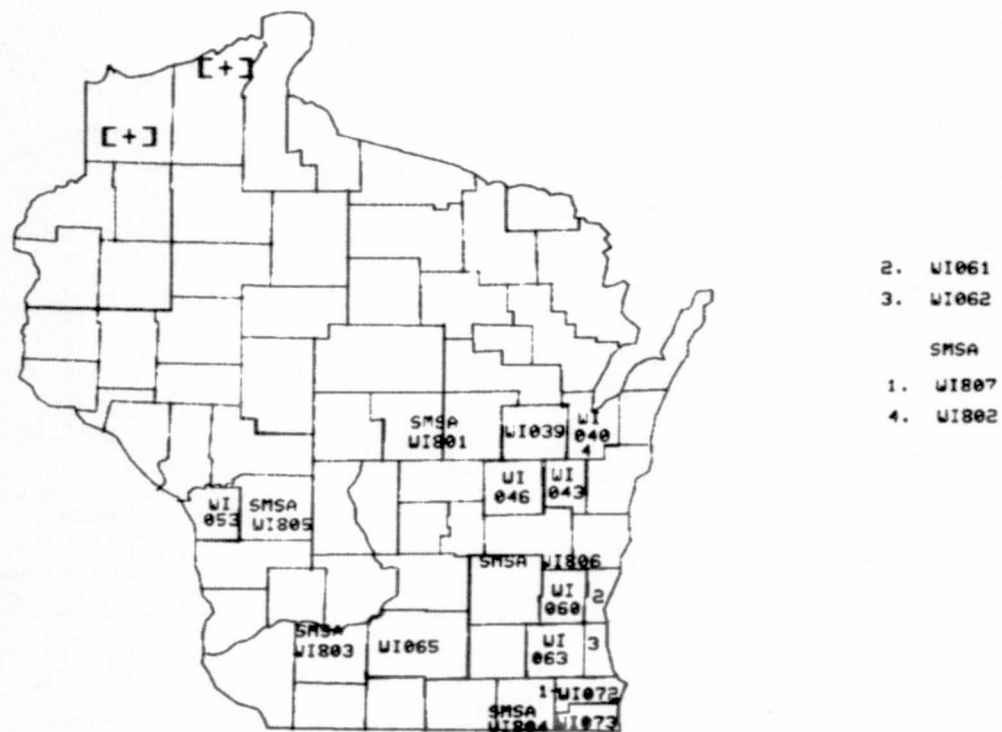


Figure 9. Rectenna locations in the state of Wisconsin.

STATE OF MICHIGAN  
[+] -- RECTENNA LOCATION

SMSA

- A. MI816
- B. MI812
- C. MI815
- D. MI814
- E. MI802
- F. MI804
- G. MI817
- H. MI809
- I. MI806
- J. MI801
- K. OH721
- L. MI813

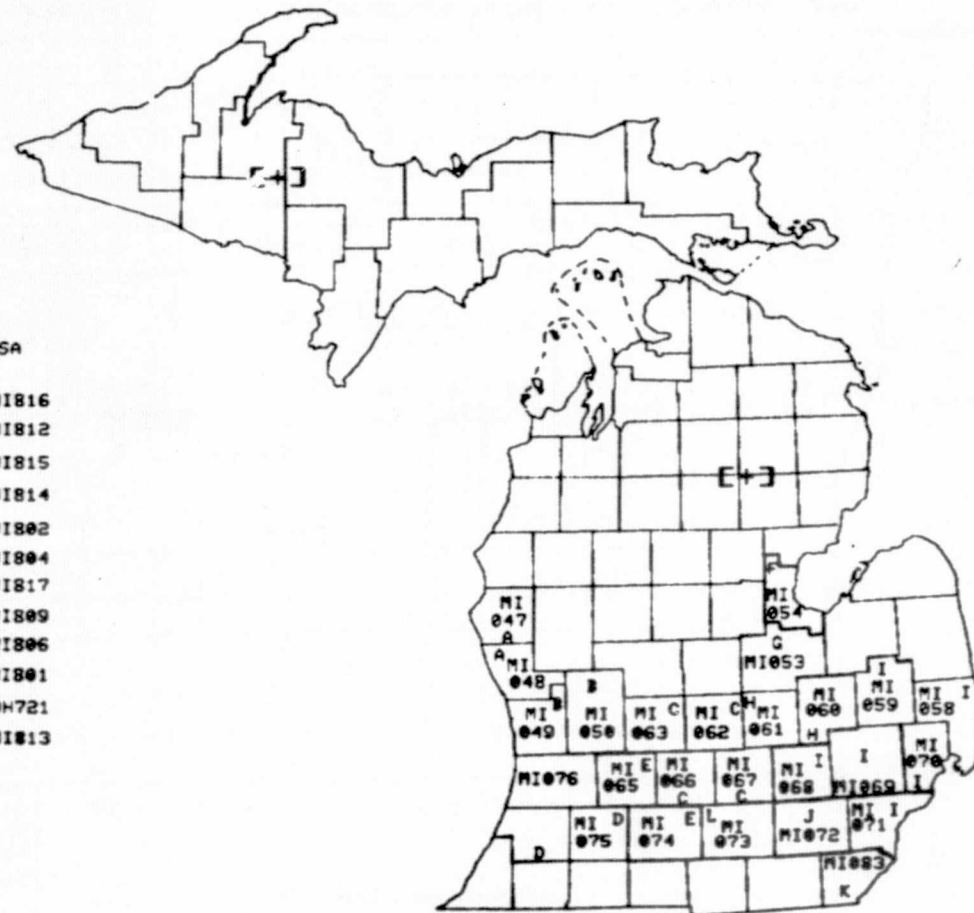


Figure 10. Rectenna locations in the state of Michigan.

ORIGINAL PAGE IS  
OF POOR QUALITY

STATE OF NORTH DAKOTA  
[+] -- RECTENNA LOCATION

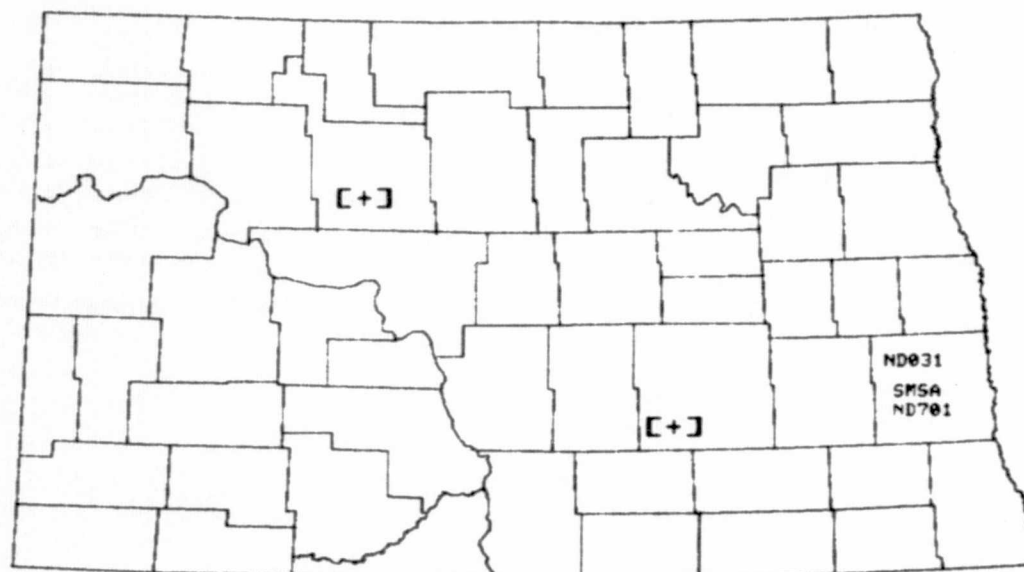


Figure 11. Rectenna locations in the state of North Dakota.

ORIGINAL PAGE IS  
OF POOR QUALITY

STATE OF SOUTH DAKOTA  
[+] -- RECTENNA LOCATION

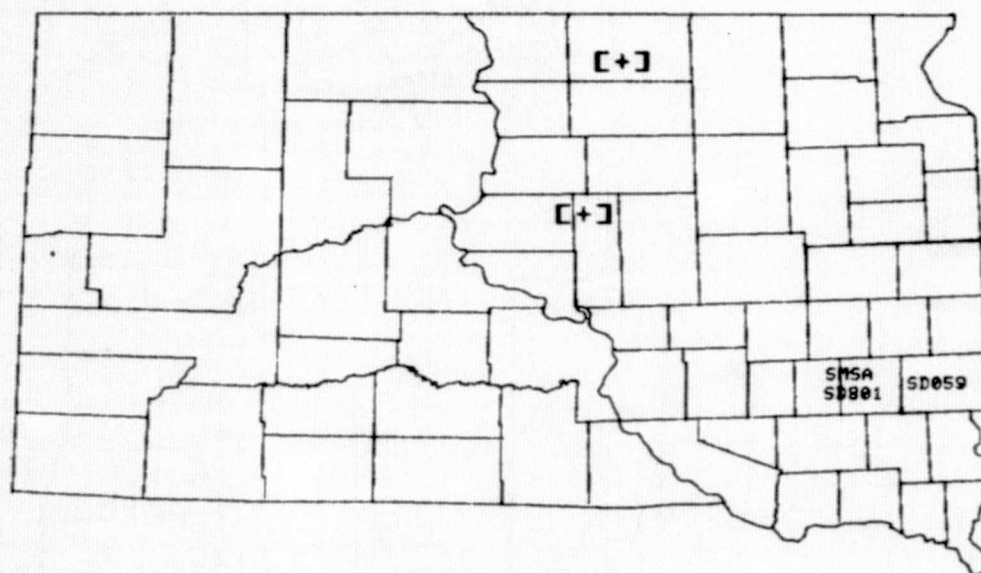


Figure 12. Rectenna locations in the state of South Dakota.

STATE OF MINNESOTA  
 [+ ] -- RECTENNA LOCATION

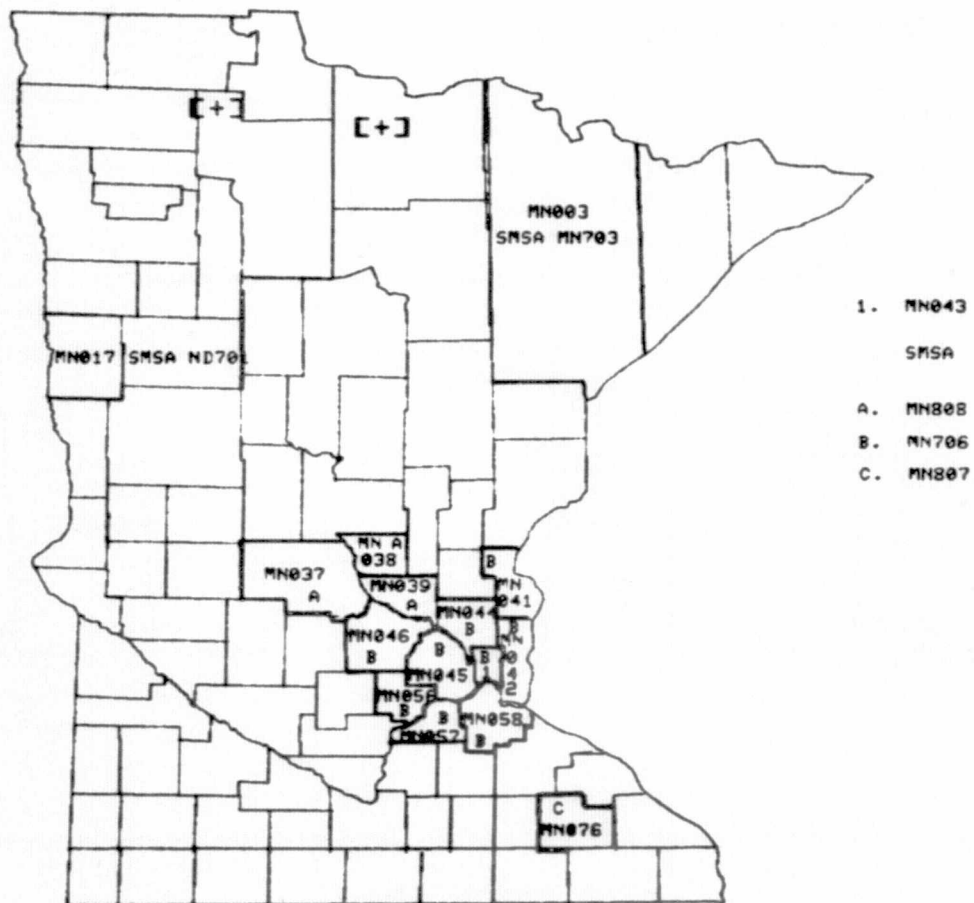
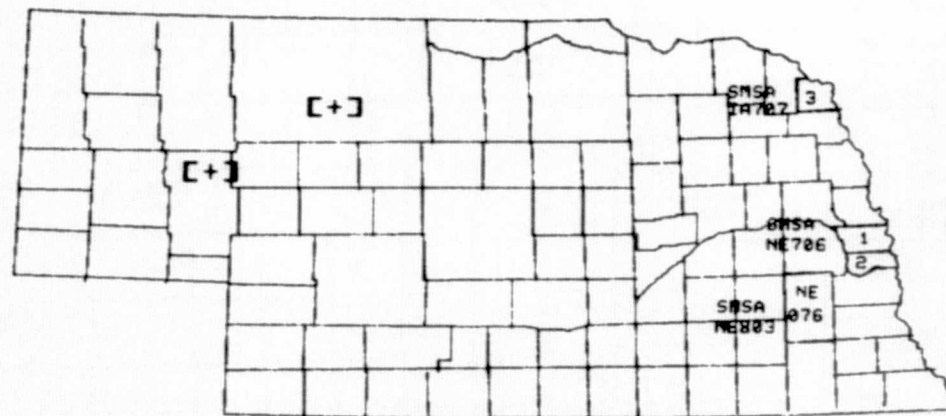


Figure 13. Rectenna locations in the state of Minnesota.

STATE OF NEBRASKA  
[+] -- RECTENNA LOCATION



1. NE052
2. NE053
3. NE017

Figure 14. Rectenna locations in the state of Nebraska.

ORIGINAL PAGE IS  
OF POOR QUALITY



## STATE OF IOWA

[+] -- RECTENNA LOCATION

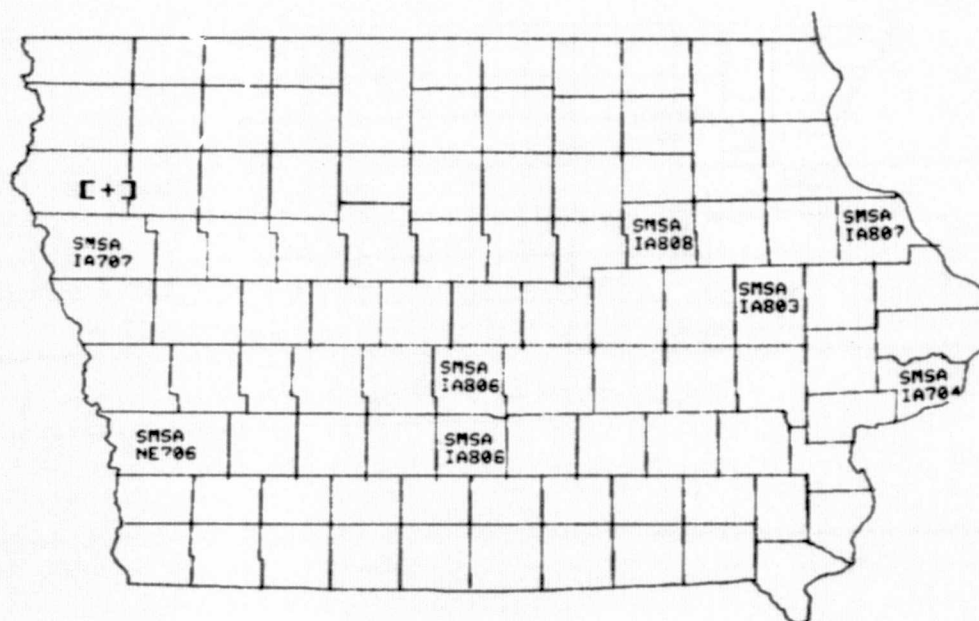


Figure 15. Rectenna location in the state of Iowa.



STATE OF KANSAS  
[+] -- RECTENNA LOCATION

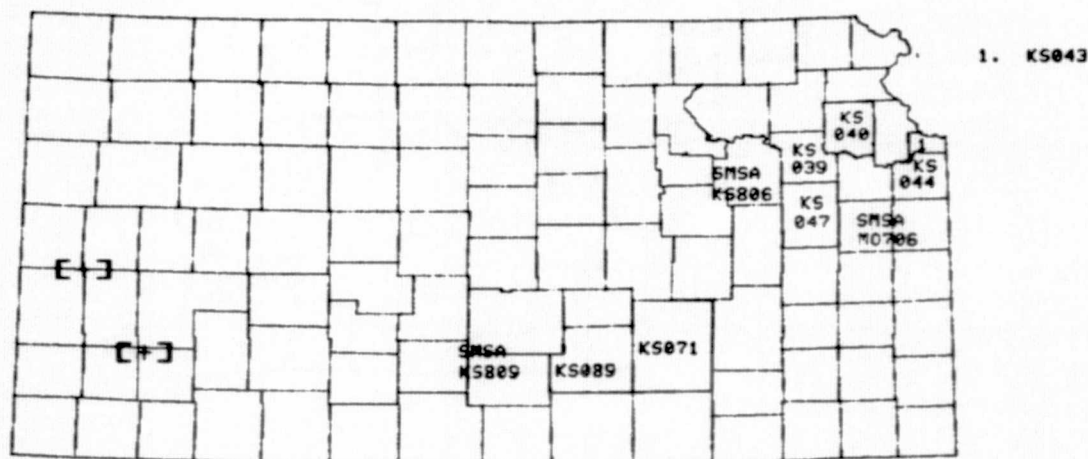


Figure 16. Rectenna locations in the state of Kansas.

ORIGINAL PAGE IS  
OF POOR QUALITY

STATE OF MISSOURI  
[+] -- RECTENNA LOCATION

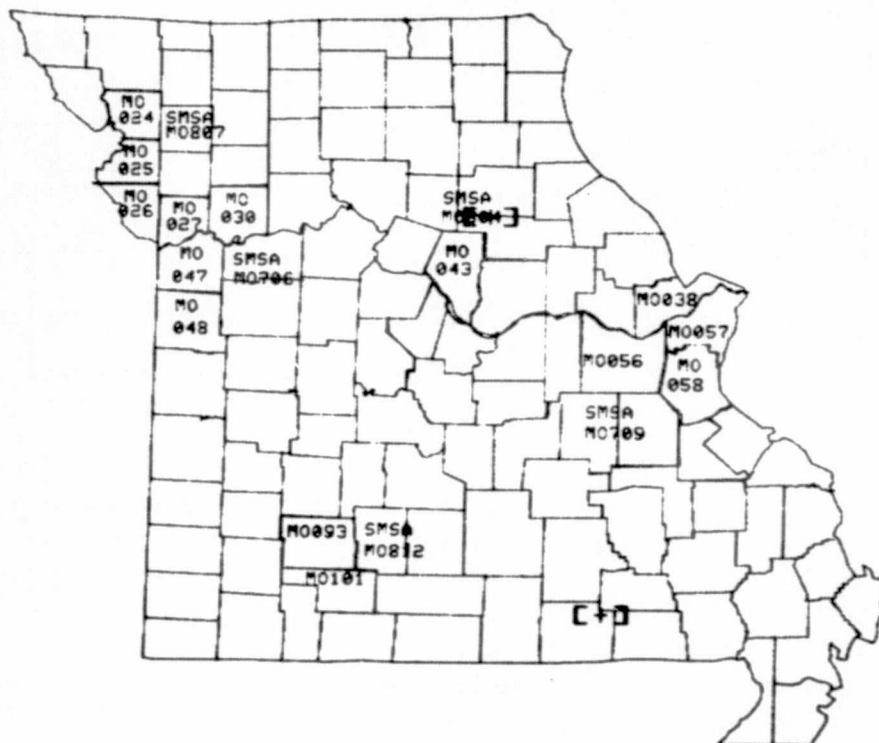


Figure 17. Rectenna locations in the state of Missouri.

STATE OF WEST VIRGINIA

[+] -- RECTENNA LOCATION

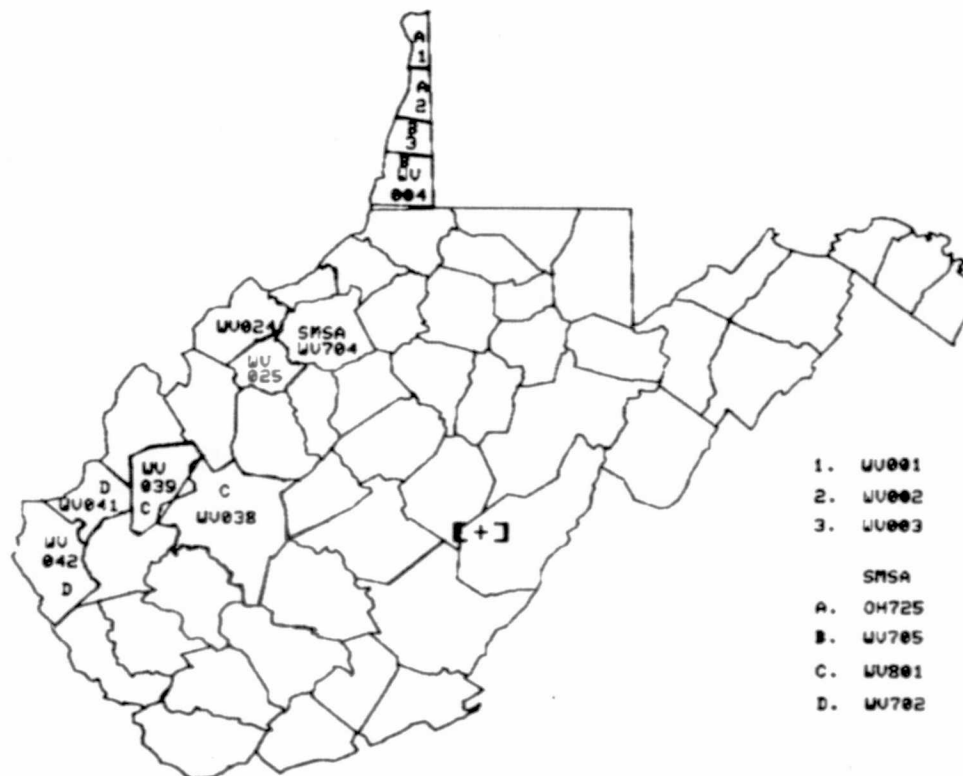


Figure 18. Rectenna location in the state of West Virginia.

ORIGINAL PAGE IS  
OF POOR QUALITY

STATE OF VIRGINIA  
[+3] -- RECTENNA LOCATION

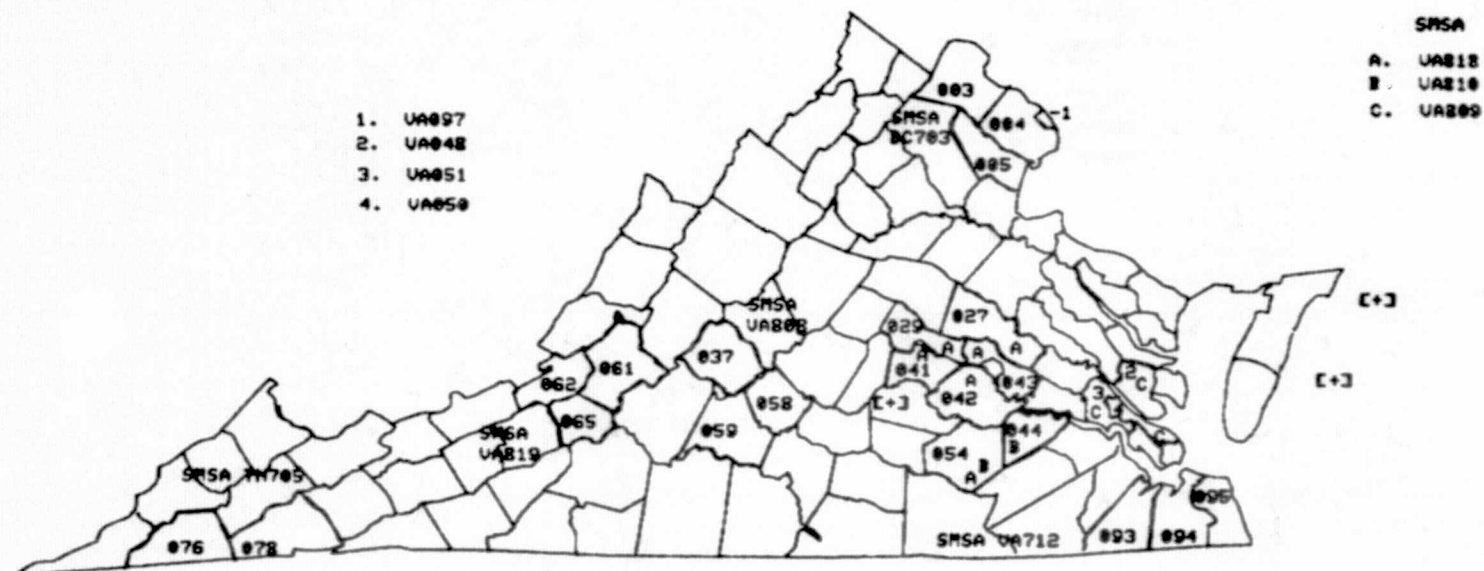


Figure 19. Rectenna locations in the state of Virginia.

STATE OF NORTH CAROLINA  
[+] -- RECTENNA LOCATION

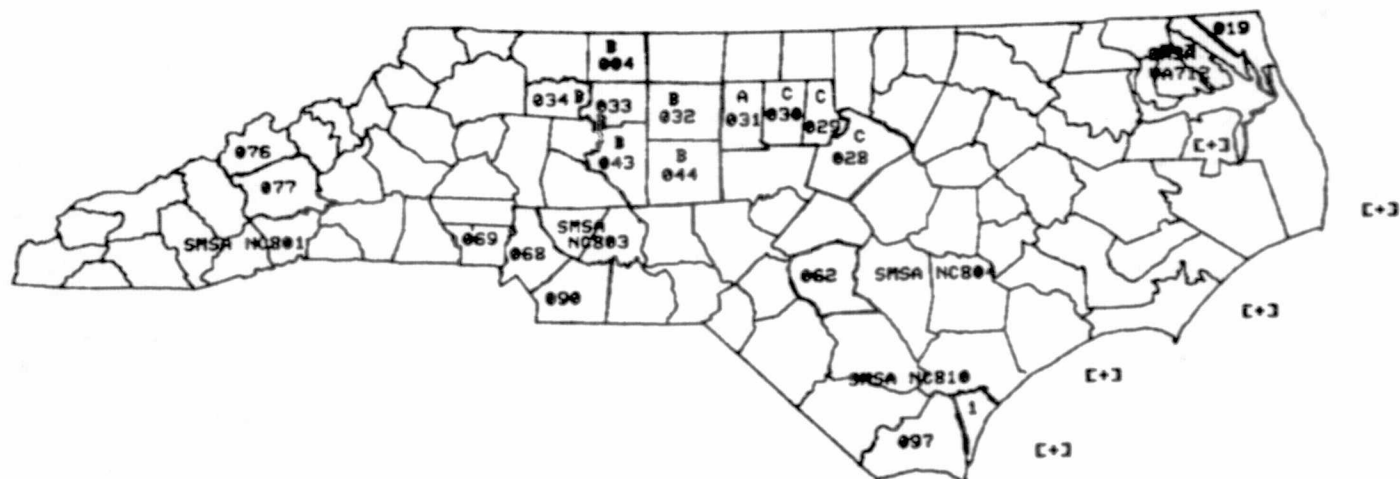


Figure 20. Rectenna locations in the state of North Carolina.

STATE OF SOUTH CAROLINA  
[+] -- RECTENNA LOCATION

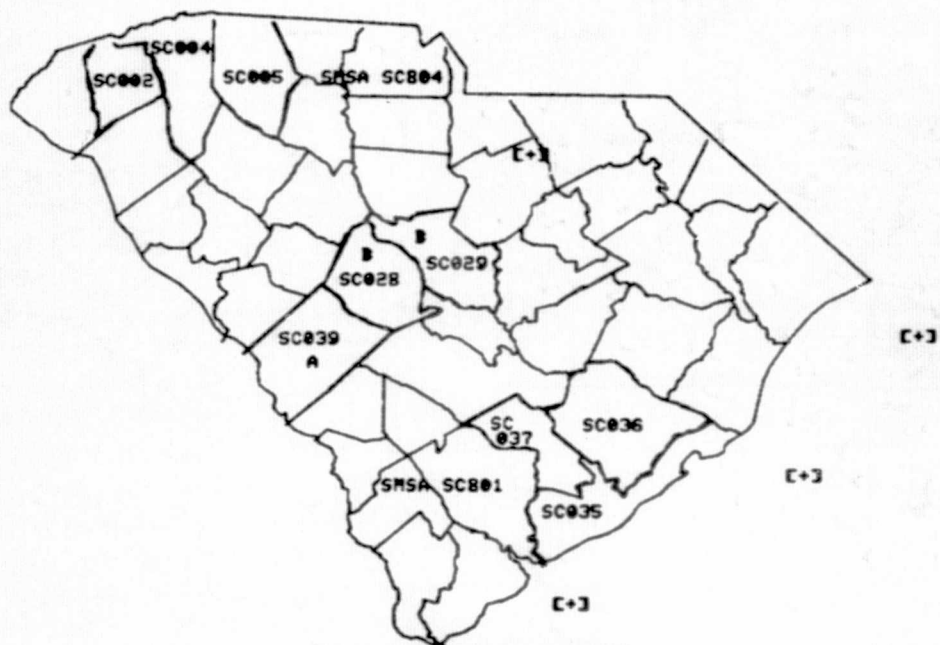


Figure 21. Rectenna locations in the state of South Carolina.

STATE OF GEORGIA  
[+J] -- RECTENNA LOCATION

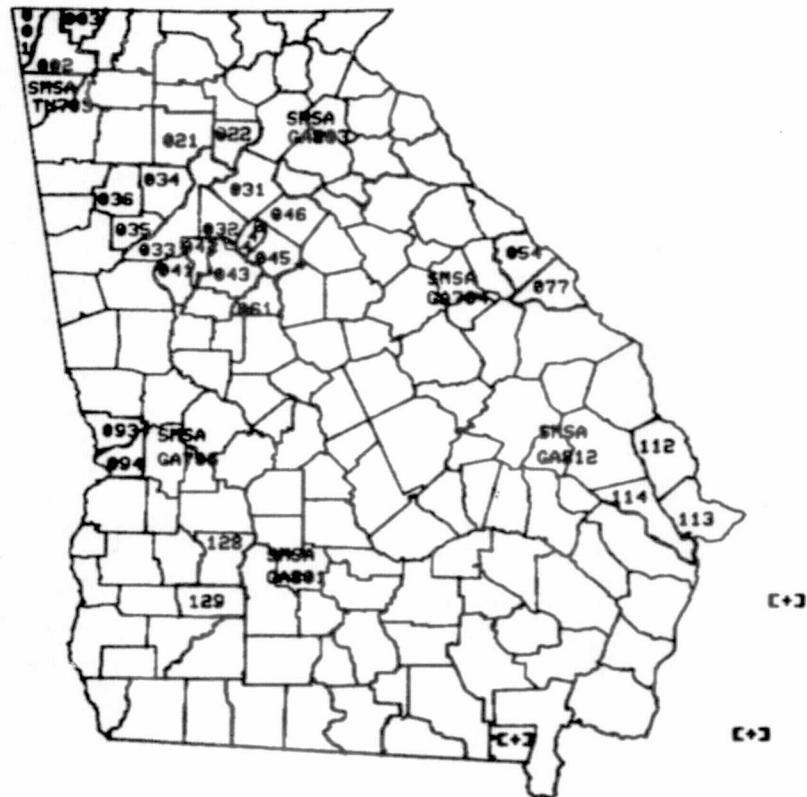


Figure 22. Rectenna locations in the state of Georgia.



STATE OF FLORIDA  
E+J -- RECTENNA LOCATION

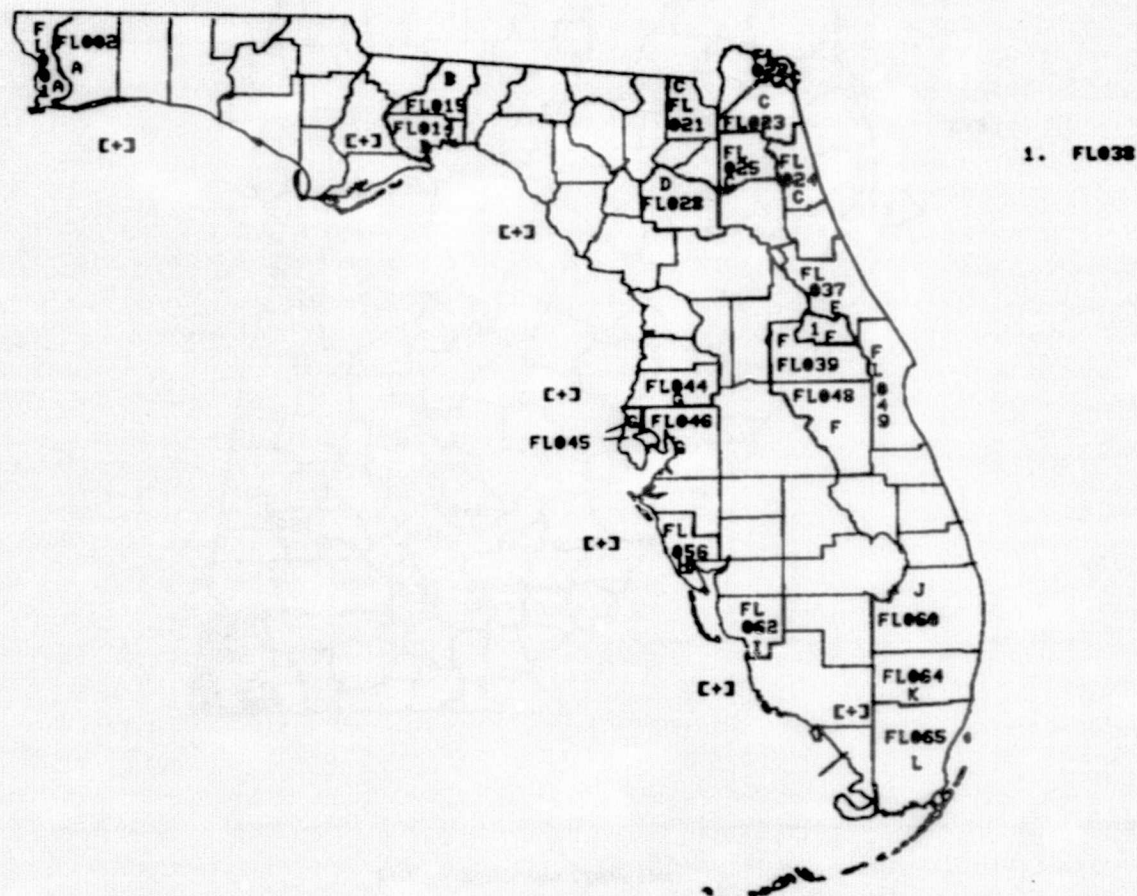
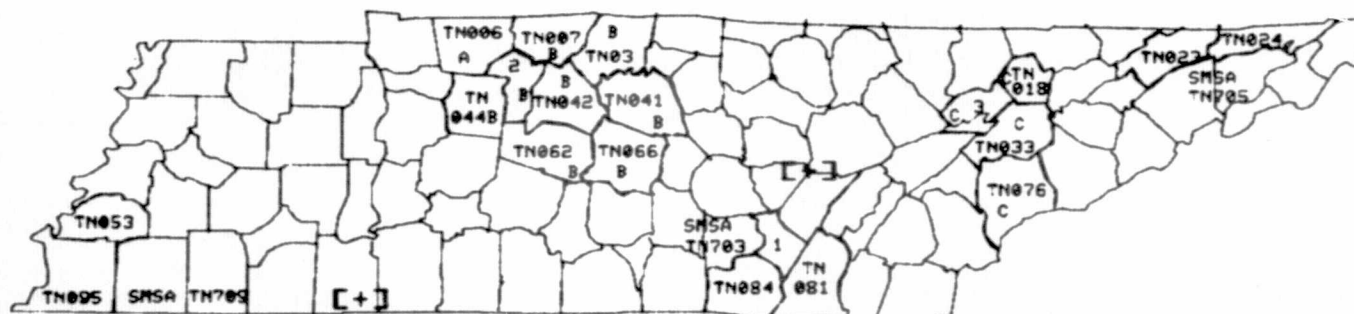


Figure 23. Rectenna locations in the state of Florida.



STATE OF TENNESSEE  
[+] -- RECTENNA LOCATION



1. TN082
2. TN043
3. TN034

- SMSA
- A. TN704
  - B. TN812
  - C. TN806

Figure 24. Rectenna locations in the state of Tennessee.

# STATE OF ALABAMA

[+] -- RECTENNA LOCATION

- SMSA
- A. AL804
  - B. AL806
  - C. AL805
  - D. AL801
  - E. AL803
  - F. AL813
  - G. AL812
  - H. AL809

SMSA TN703  
AL001, AL003, AL002

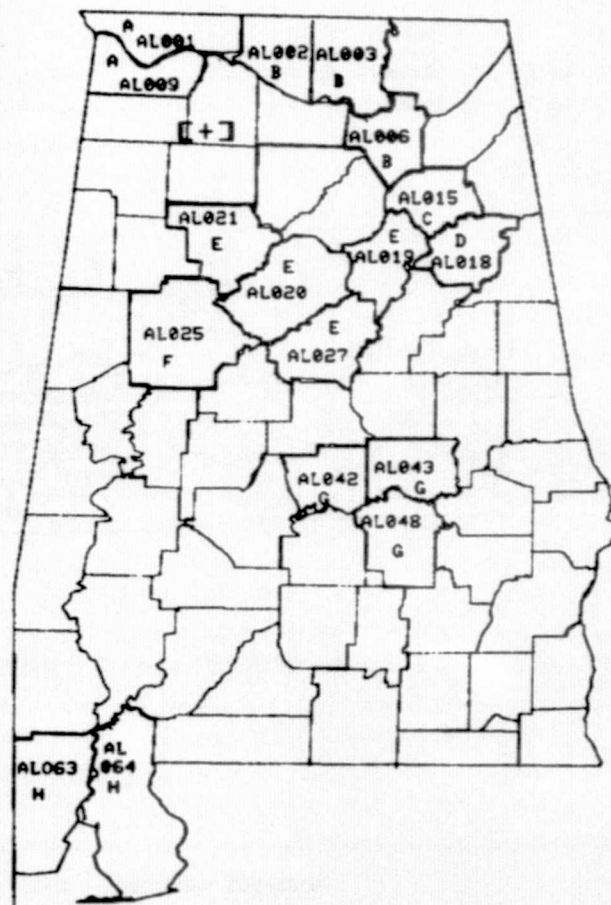


Figure 25. Rectenna location in the state of Alabama.

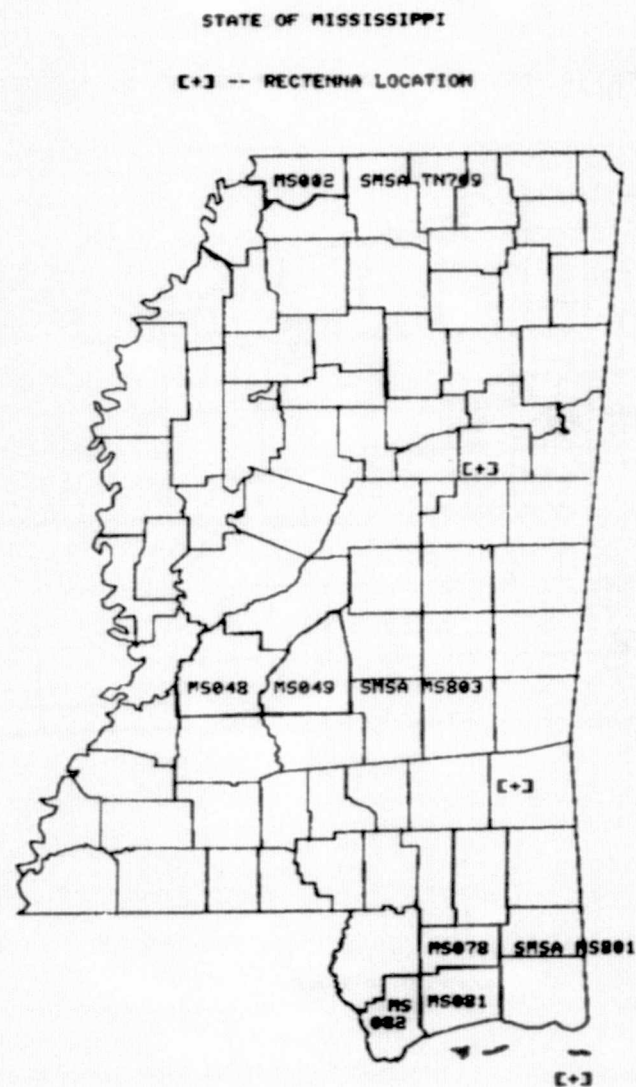


Figure 26. Rectenna locations in the state of Mississippi.

STATE OF OKLAHOMA  
[+] -- RECTENNA LOCATION

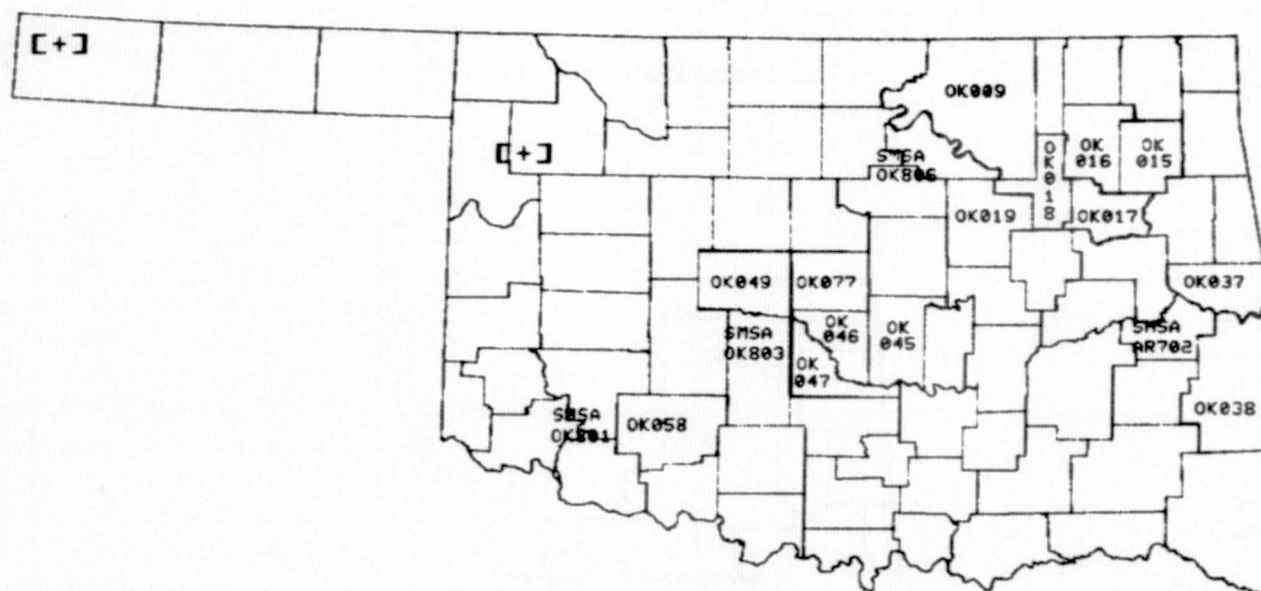


Figure 27. Rectenna locations in the state of Oklahoma.

STATE OF ARKANSAS  
 [+ ] -- RECTENNA LOCATION



Figure 28. Rectenna locations in the state of Arkansas.

ORIGINAL PAGE IS  
 OF POOR QUALITY



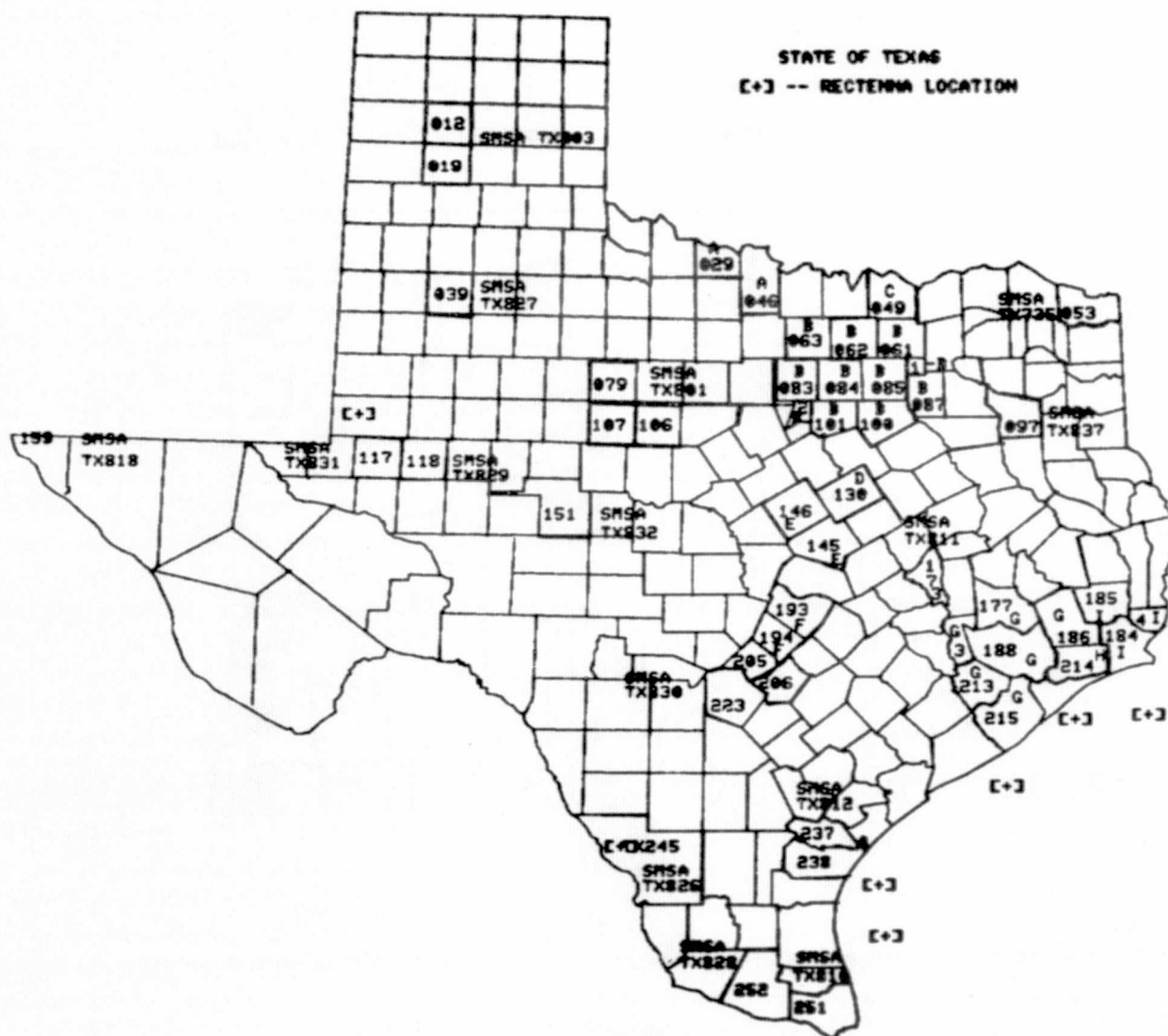


Figure 29. Rectenna locations in the state of Texas.

STATE OF LOUISIANA  
[+] -- RECTENNA LOCATION

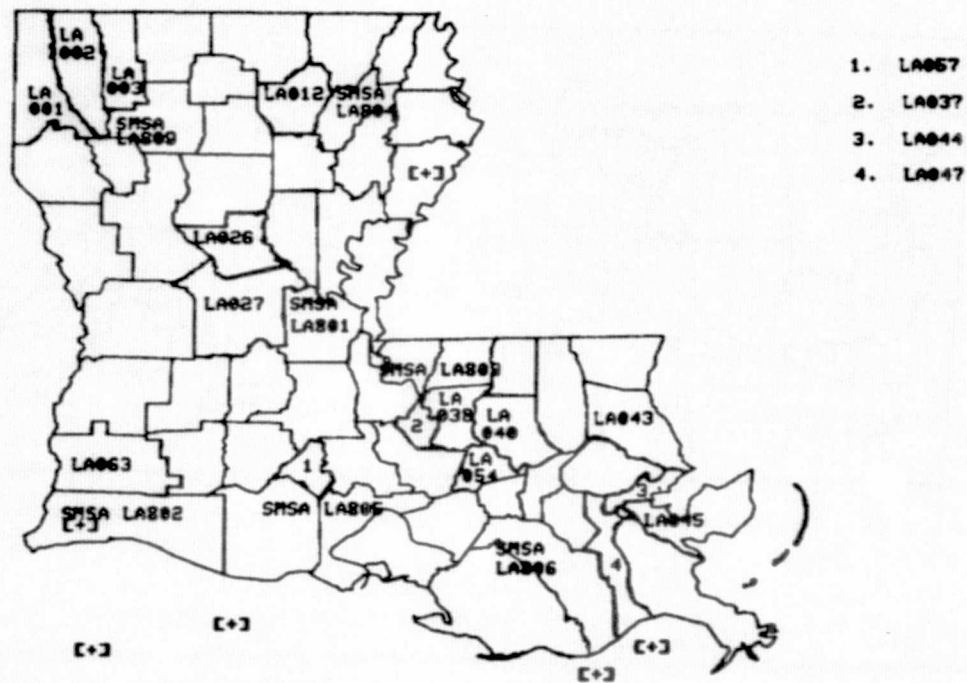


Figure 30. Rectenna locations in the state of Louisiana.

STATE OF MONTANA  
[+] -- RECTENNA LOCATION

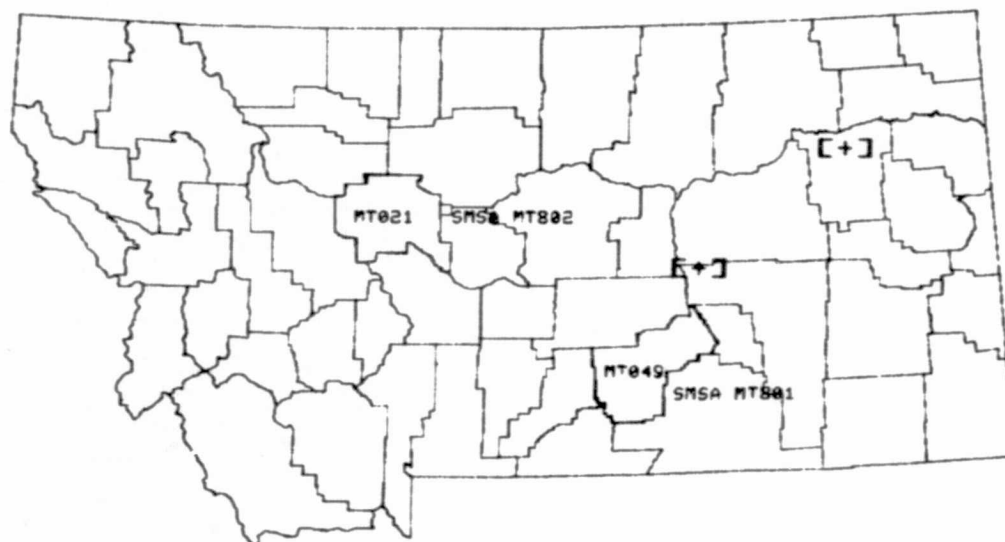


Figure 31. Rectenna locations in the state of Montana.



STATE OF IDAHO  
[+] -- RECTENNA LOCATION

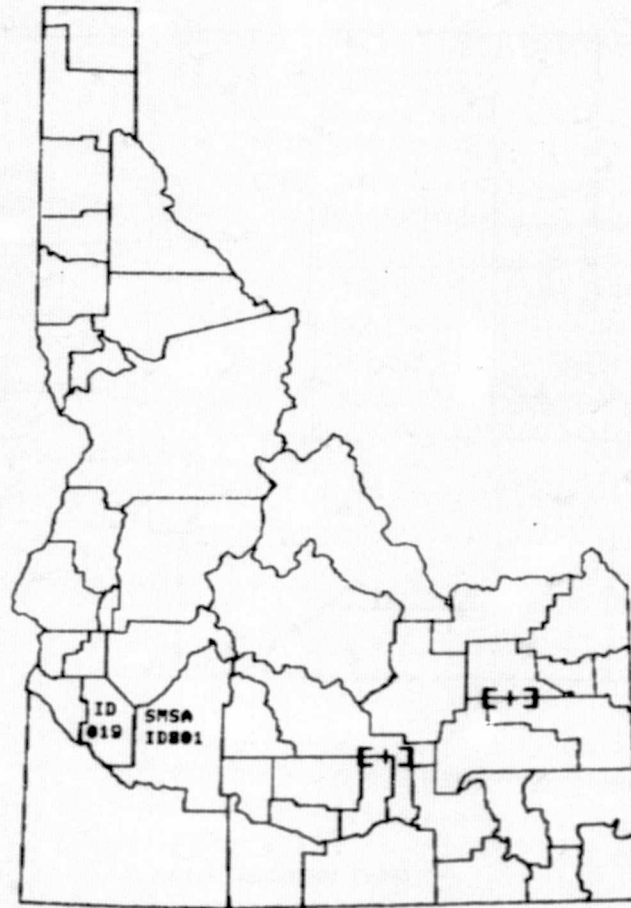


Figure 32. Rectenna locations in the state of Idaho.

STATE OF WYOMING  
[+] -- RECTENNA LOCATION

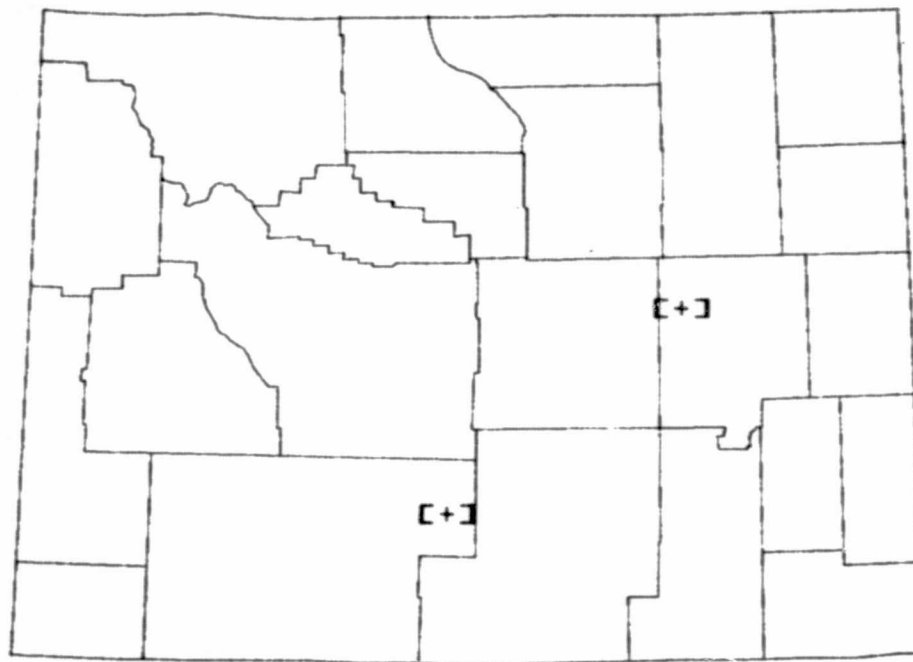


Figure 33. Rectenna locations in the state of Wyoming.

STATE OF NEVADA  
[+] -- RECTENNA LOCATION

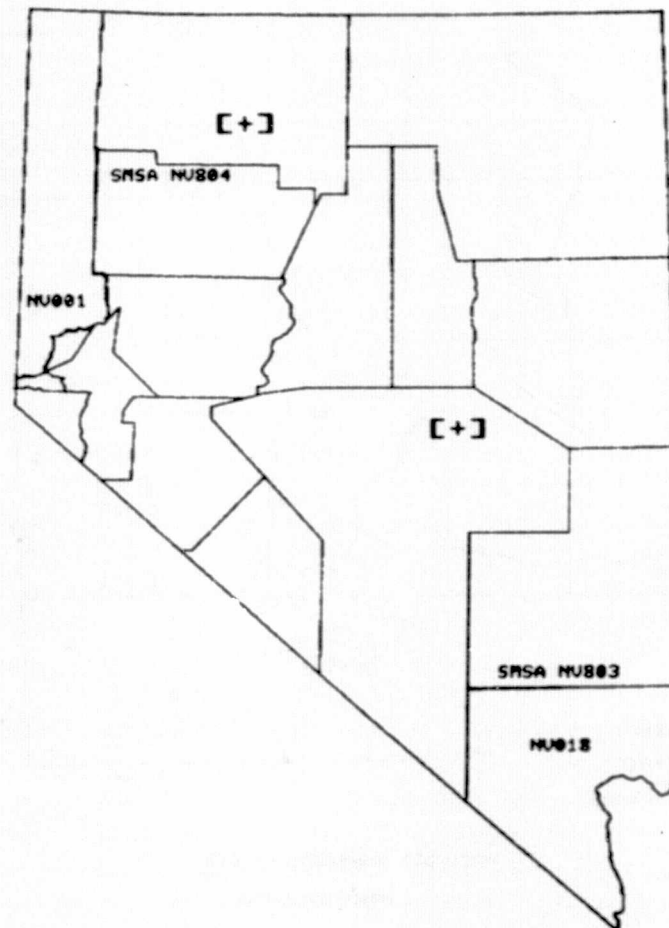


Figure 34. Rectenna locations in the state of Nevada.

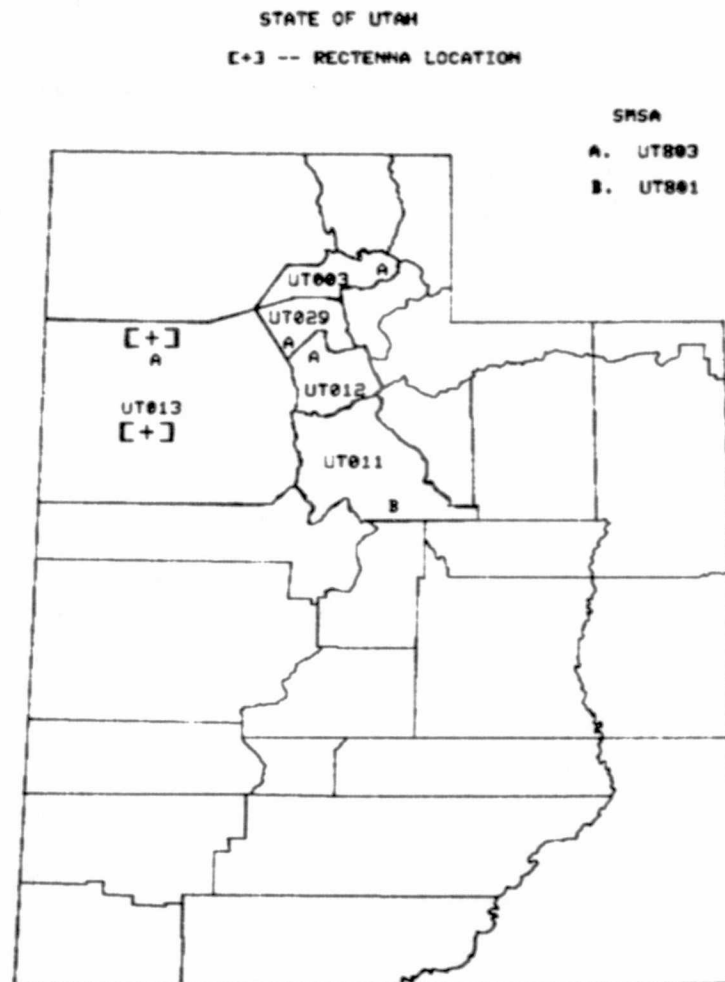


Figure 35. Rectenna locations in the state of Utah.

STATE OF COLORADO  
[+] -- RECTENNA LOCATION

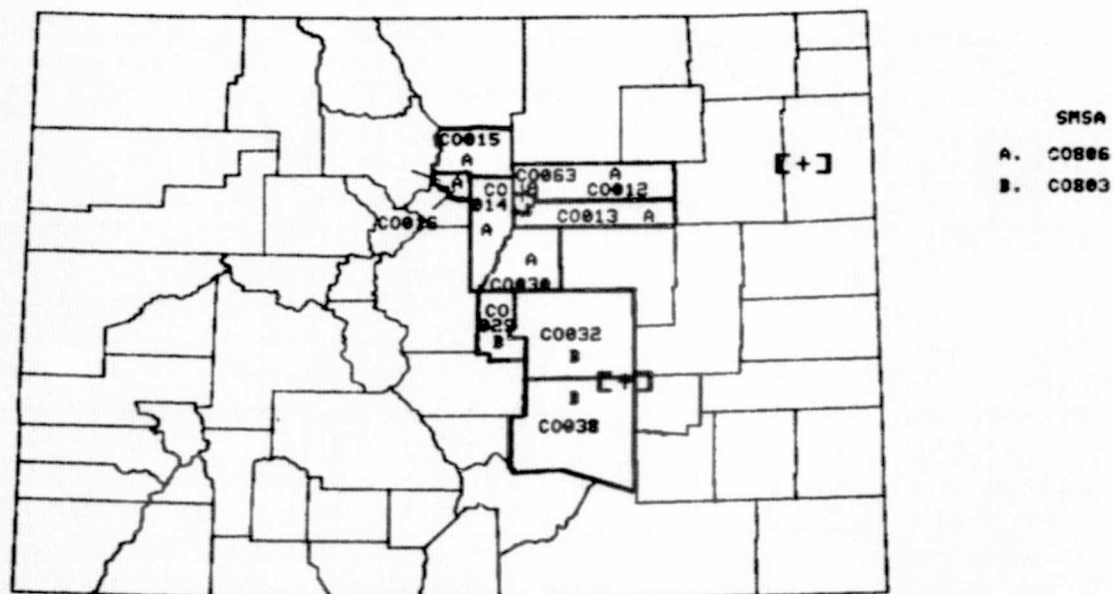


Figure 36. Rectenna locations in the state of Colorado.

## STATE OF ARIZONA

[+] -- RECTENNA LOCATION

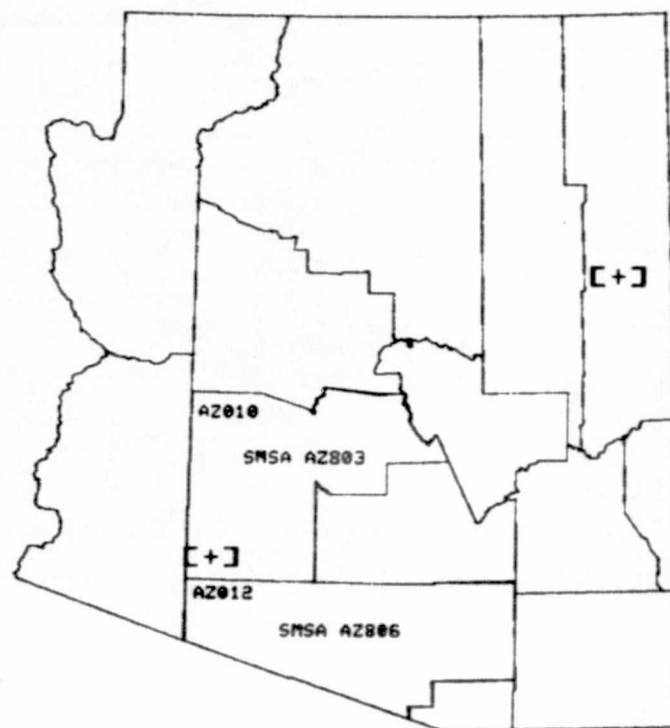


Figure 37. Rectenna locations in the state of Arizona.

STATE OF NEW MEXICO  
[+] -- RECTENNA LOCATION

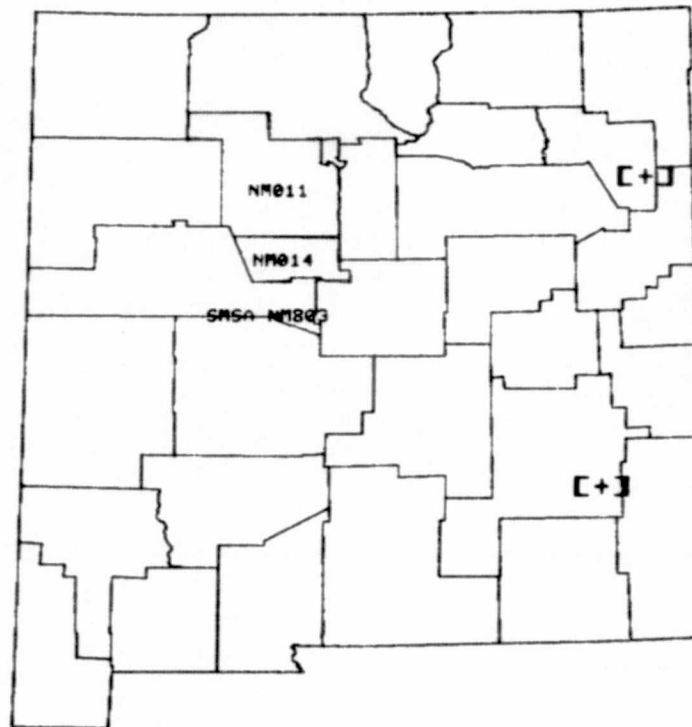


Figure 38. Rectenna locations in the state of New Mexico.

STATE OF WASHINGTON  
E+J -- RECTENNA LOCATION

SMSA  
A. UA803  
B. UA817

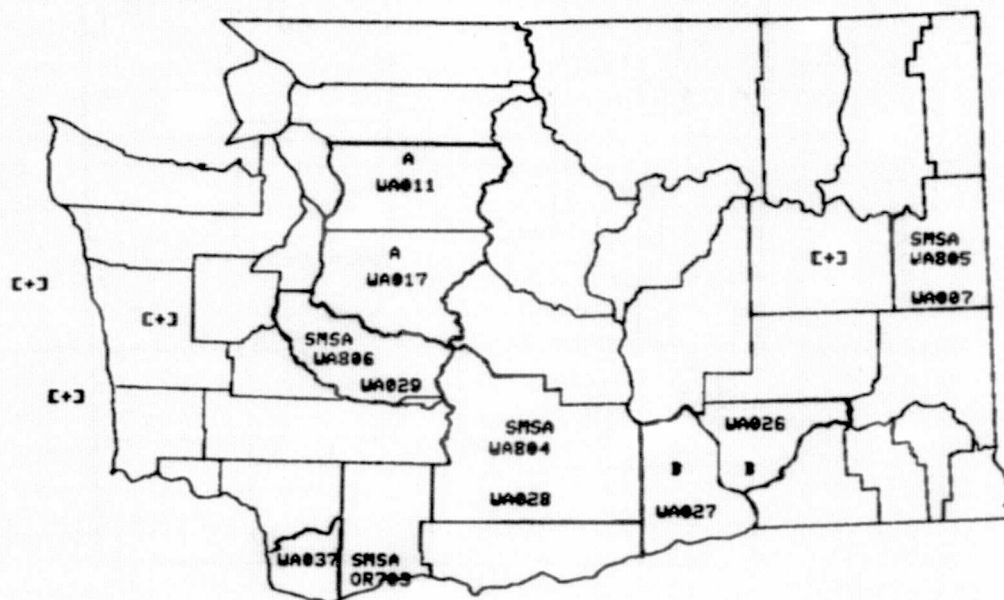


Figure 39. Rectenna locations in the state of Washington.



STATE OF OREGON  
[+] -- RECTENNA LOCATION

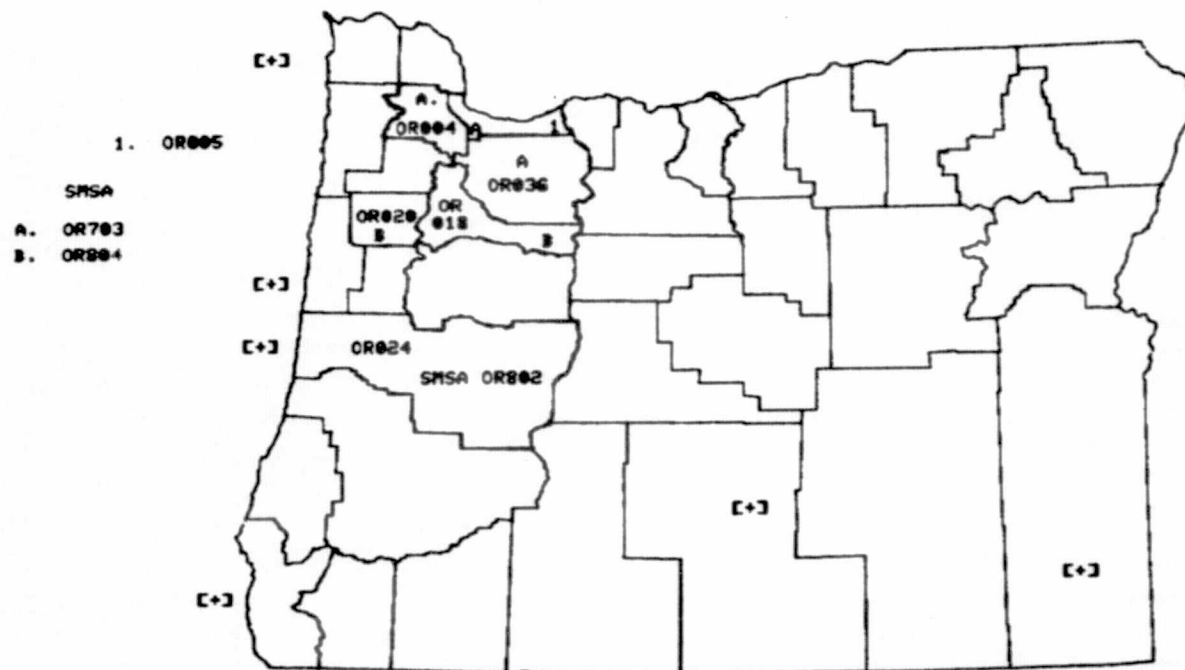


Figure 40. Rectenna locations in the state of Oregon.

ORIGINAL PAGE IS  
OF POOR QUALITY

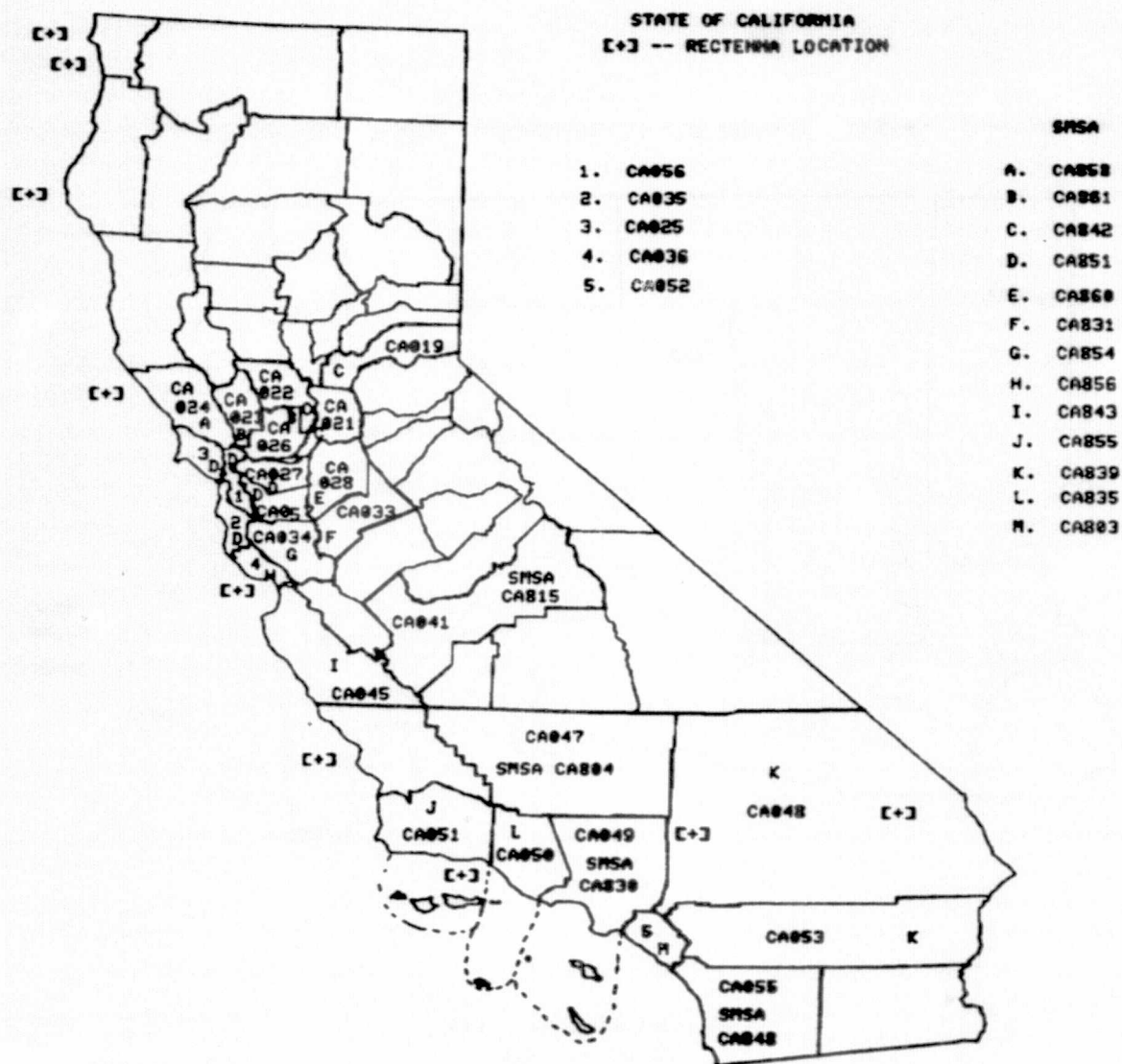


Figure 41. Rectenna locations in the state of California.



Figure 42. Rectenna distribution through the nine regions of the country.  
(Rectennas are not to scale.)

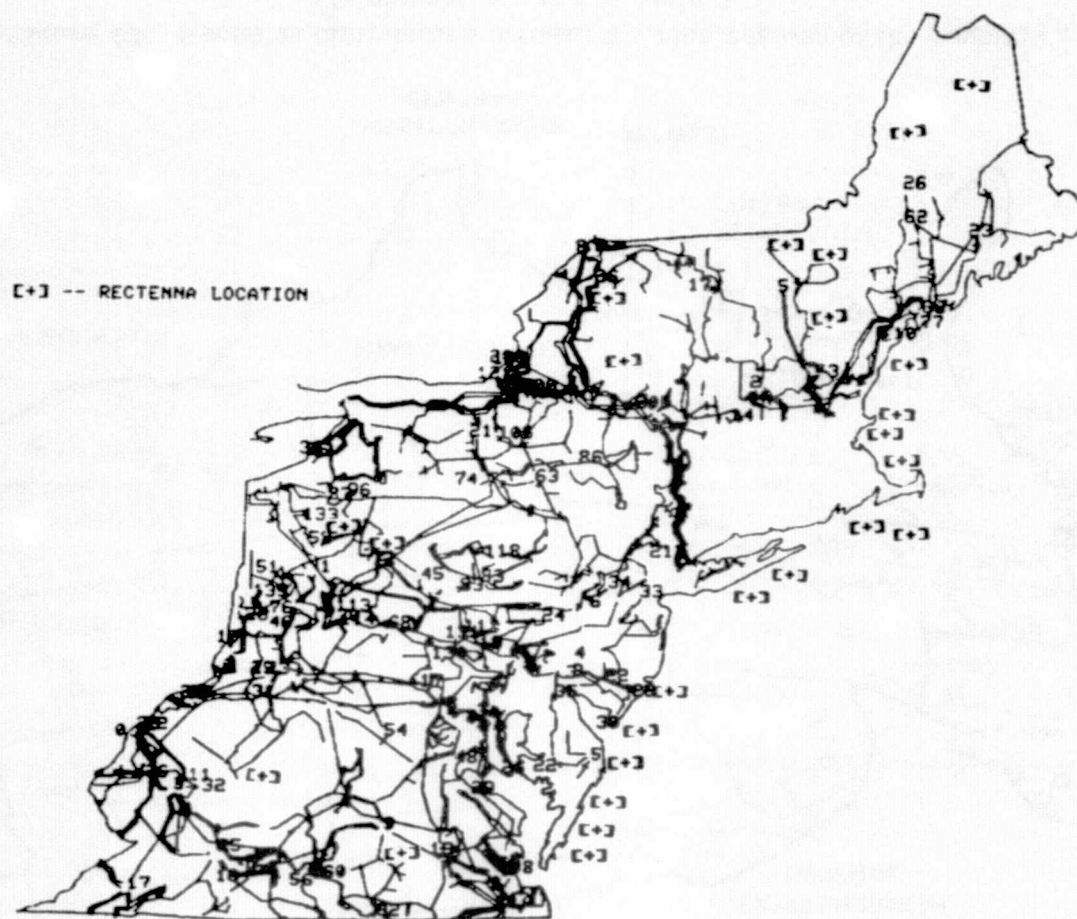


Figure 43. Rectenna locations overlaid on principal electric facilities in the Northeastern U.S.

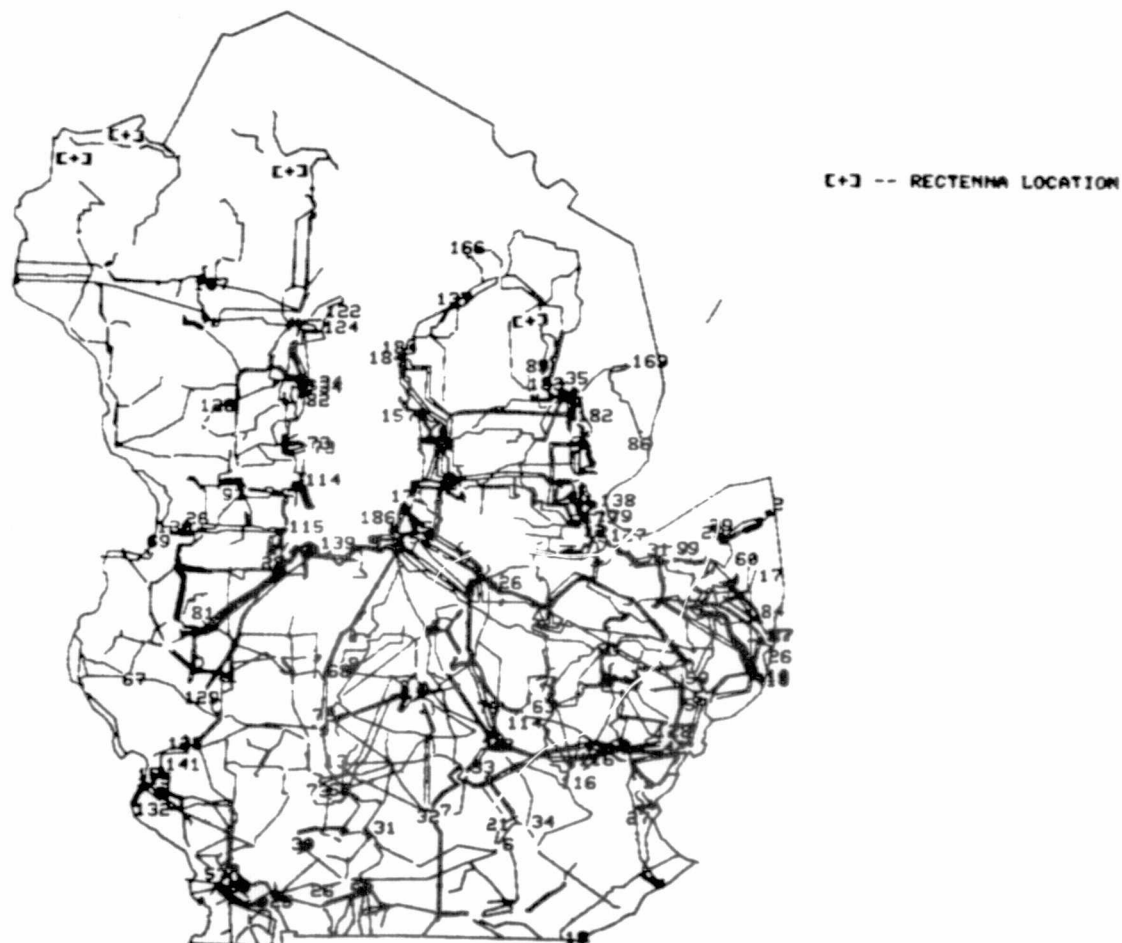


Figure 44. Rectenna locations overlaid on principal electric facilities in the Eastern North Central U.S.

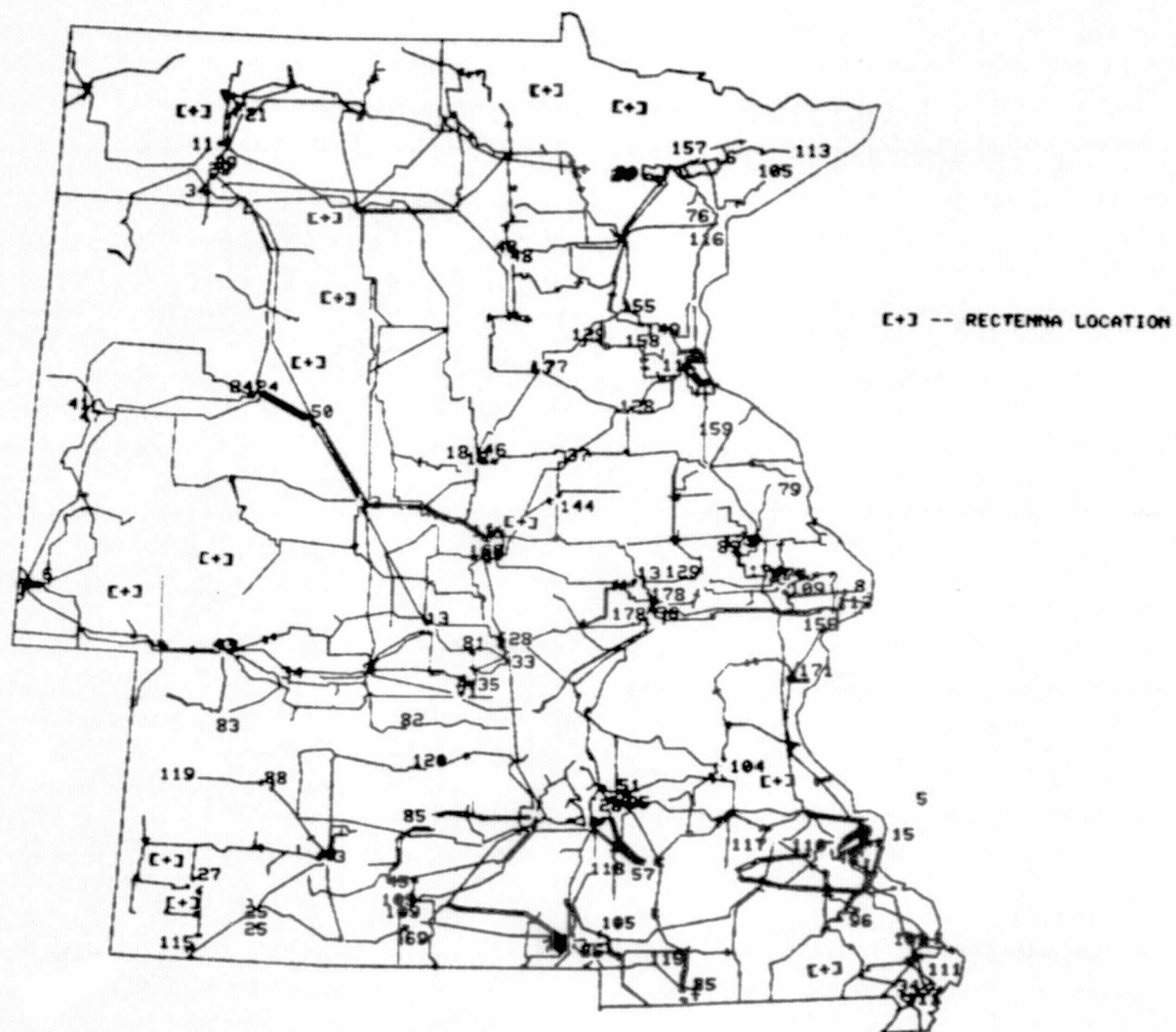
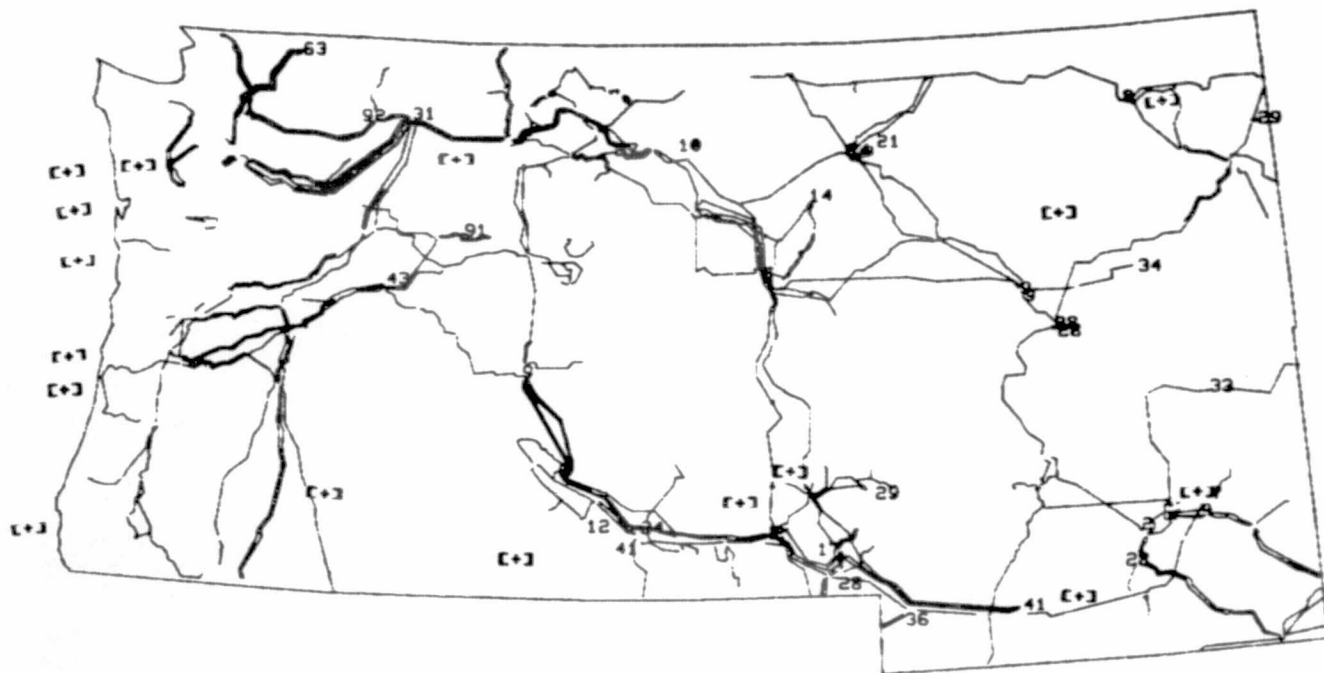


Figure 45. Rectenna locations overlaid on principal electric facilities in the Western North Central U.S.



[+] -- RECTENNA LOCATION

Figure 46. Rectenna locations overlaid on principal electric facilities in the Pacific Northwestern U.S.



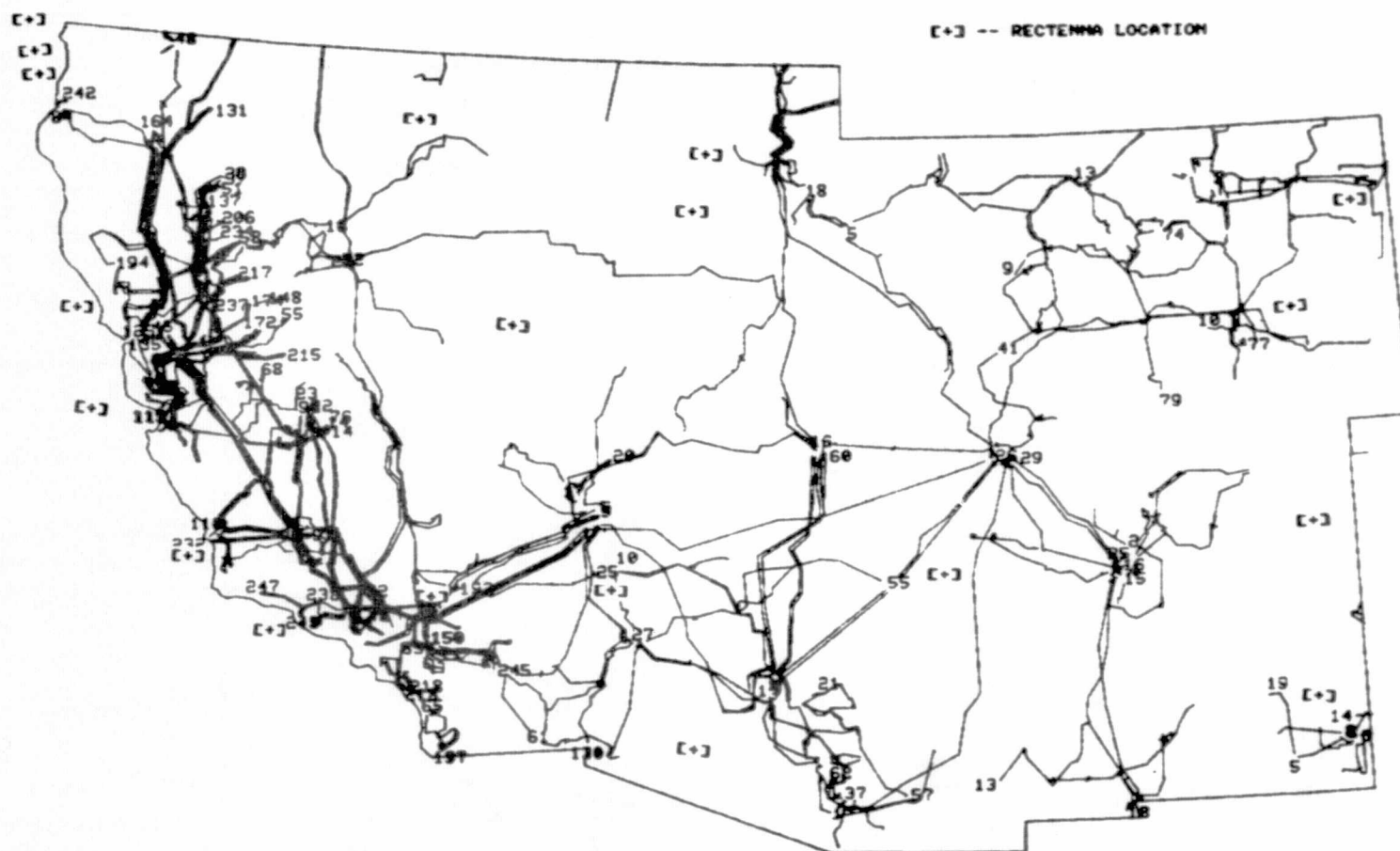


Figure 47. Rectenna locations overlaid on principal electric facilities in the Southwestern U.S.



ORIGINAL PAGE IS  
OF POOR QUALITY

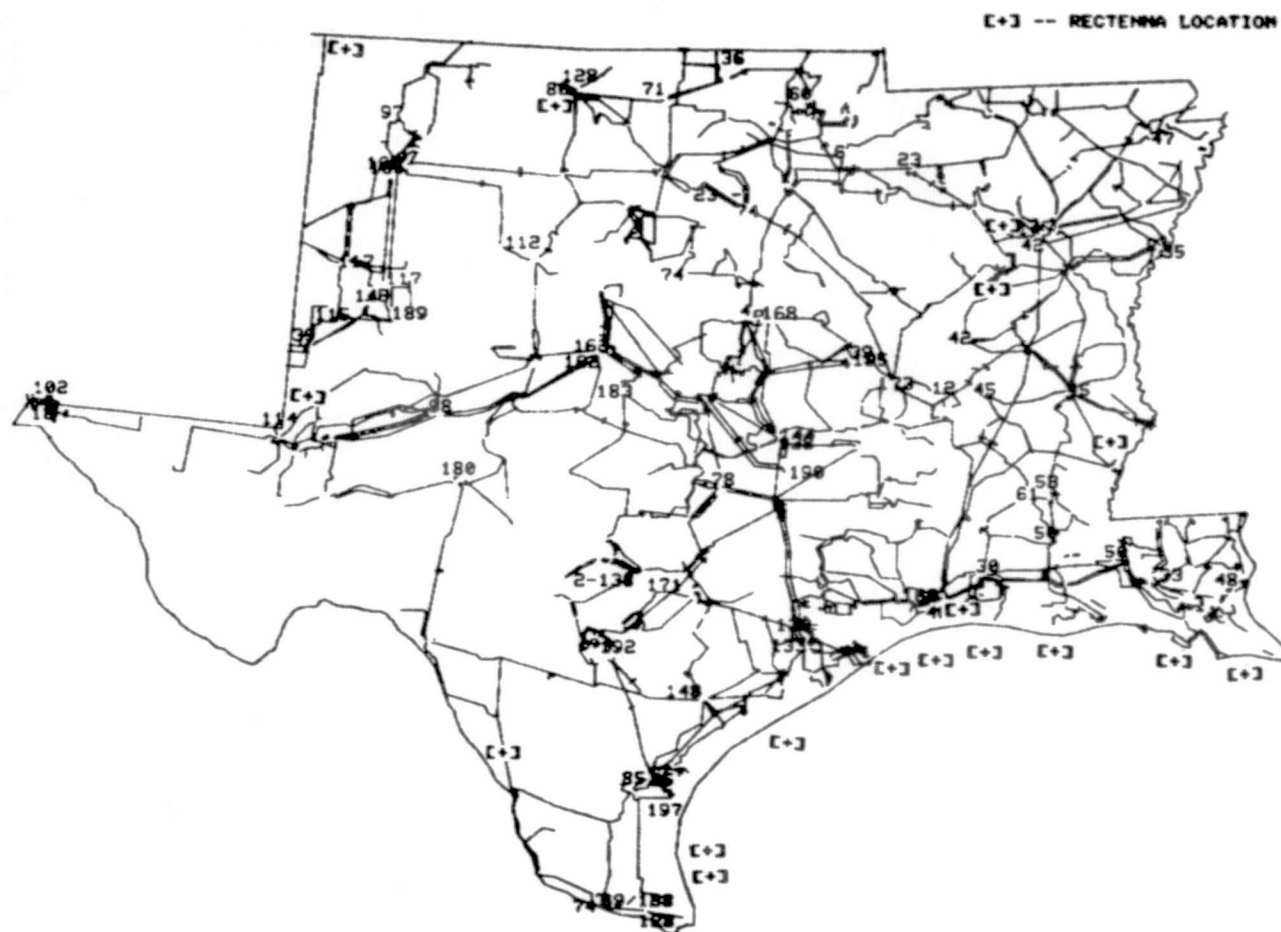


Figure 48. Rectenna locations overlaid on principal electric facilities in the South Central U.S.

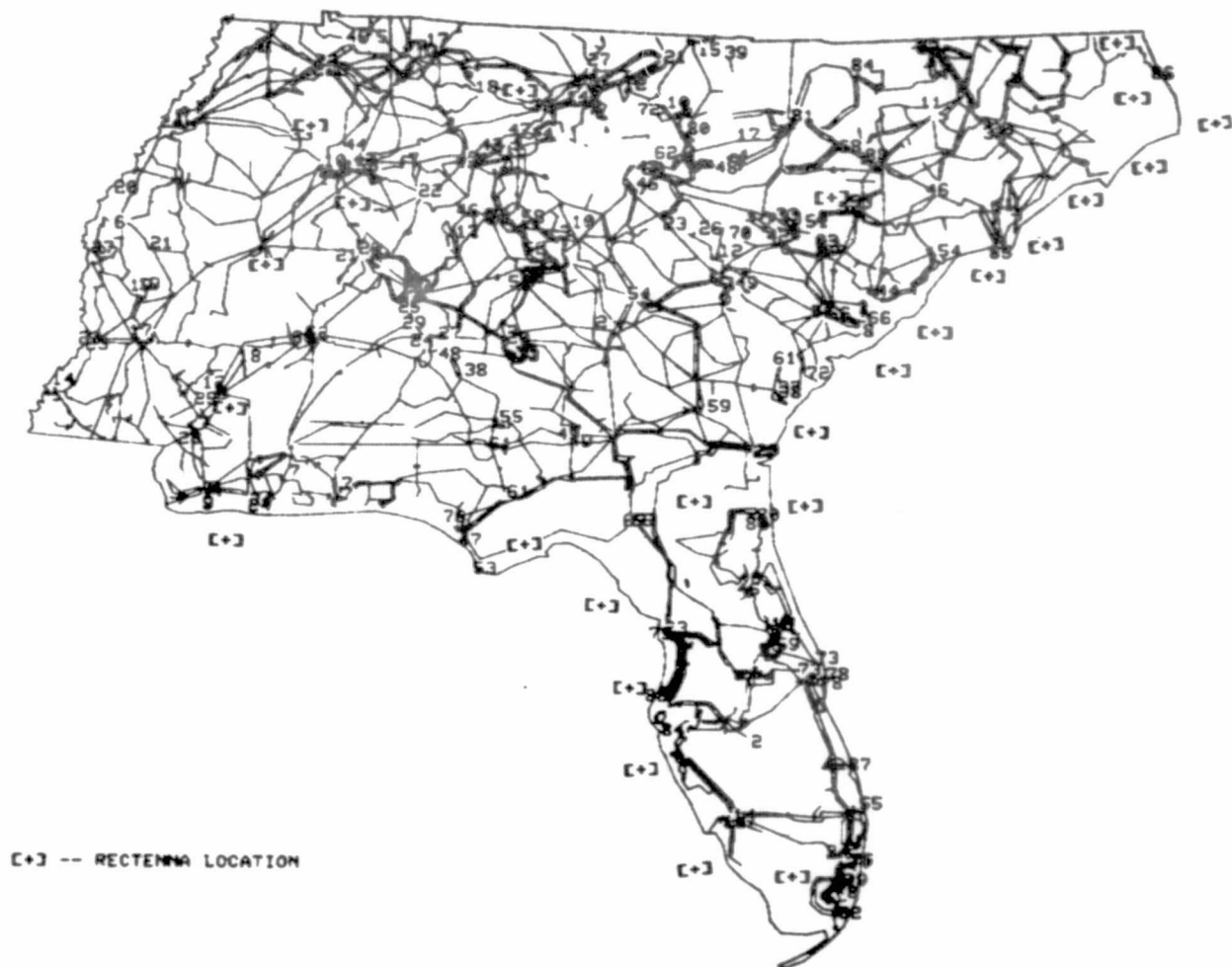


Figure 49. Rectenna locations overlaid on principal electric facilities in the Southeastern U.S.

STATE OF MASSACHUSETTS  
 E+J -- RECTENNA LOCATION

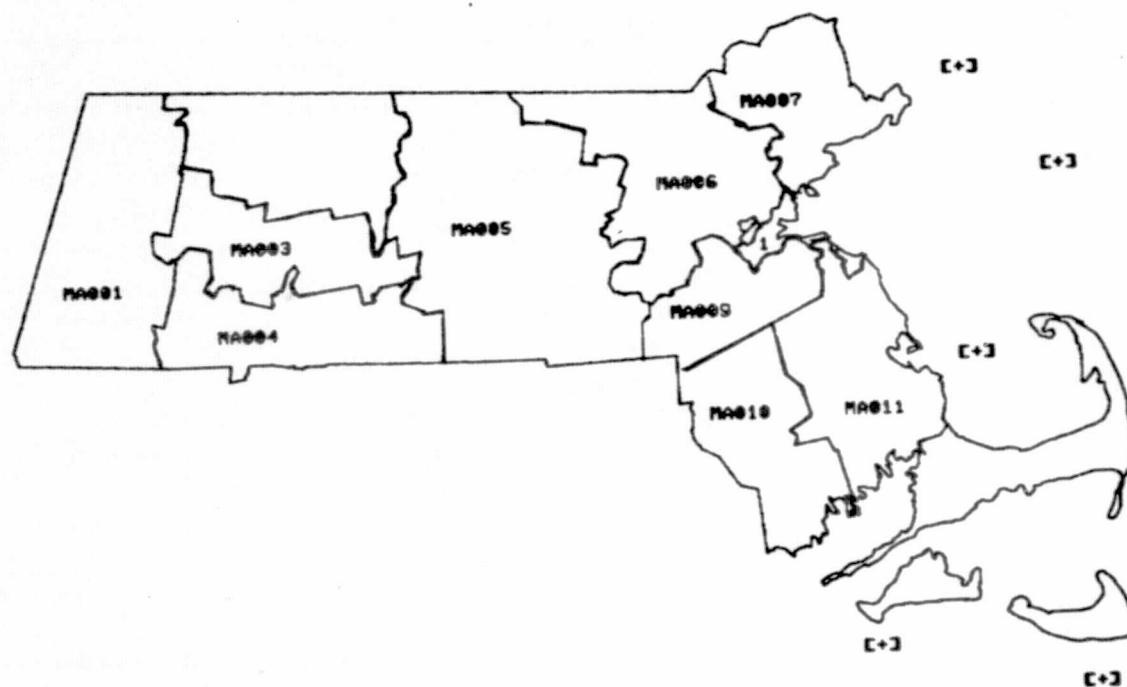


Figure 50. Rectenna locations in the state of Massachusetts.

STATE OF NEW JERSEY  
E+3 -- RECTENNA LOCATION



Figure 51. Rectenna locations in the state of New Jersey.

STATE OF DELAWARE  
[+] -- RECTENNA LOCATION

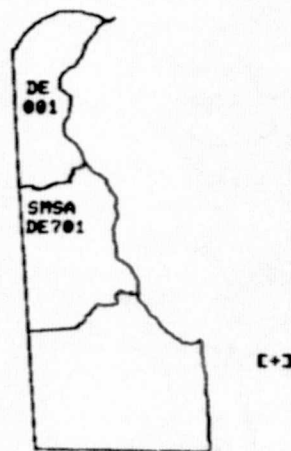


Figure 52. Rectenna location in the state of Delaware.

STATE OF MARYLAND  
E+3 -- RECTENNA LOCATION

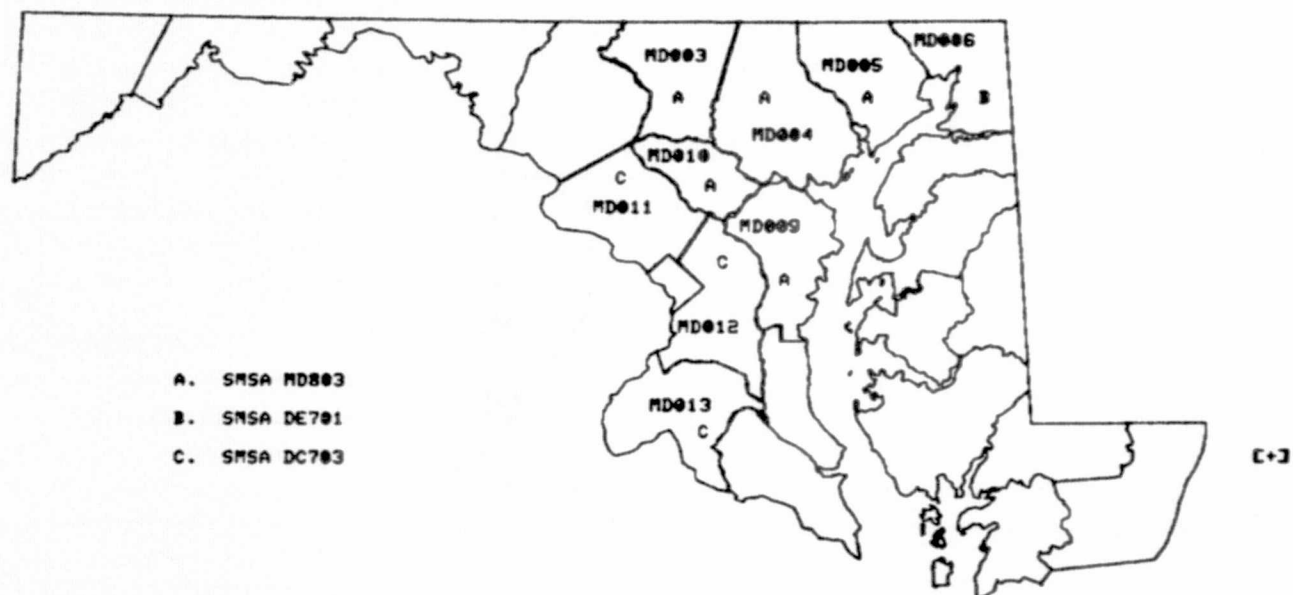


Figure 53. Rectenna location in the state of Maryland.

## REFERENCES

1. Satellite Power System Study Status, Program Development, MSFC, Study Paper, June 1977.
2. U.S. Bureau of the Census, Statistical Abstract of the United States: 1976 (97th Edition), No. 927, Washington, D.C., 1976, p. 559.
3. U.S. Bureau of the Census, Statistical Abstract of the United States: 1976 (97th Edition), No. 10, Washington, D.C., 1976, p. 11.
4. U.S. Bureau of the Census, Statistical Abstract of the United States: 1976 (97th Edition), No. 303, Washington, D.C., 1976, p. 180.
5. The National Atlas of the United States of America, Land Usage Map, 1970, pp. 158-159.
6. The National Atlas of the United States of America, Population Density Map, 1970, p. 241.
7. The National Atlas of the United States of America, Air Flights and Facilities Map, 1970, pp. 232-233.
8. Rand McNally Standard State Maps.
9. Rand McNally's Road and Reference Atlas, State Highway Maps, 1970, pp. 4-91.
10. The National Atlas of the United States of America, Elevation Characteristics Map, 1970, pp. 62-63.
11. The National Atlas of the United States of America, Regional Maps, 1970, pp. 6-36.
12. Federal Power Commission Maps of Principal Electric Facilities.
13. U.S. Bureau of the Census, Statistical Abstract of the United States: 1976 (97th Edition), No. 6, Washington, D.C., 1976, p. 9.
14. U.S. Bureau of the Census, Statistical Abstract of the United States: 1976 (97th Edition), No. 7, Washington, D.C., 1976, p. 9.
15. NOAA Coastal Charts.

## APPENDIX



**TABLE A-1. ALPHABETICAL LISTING OF STATES DESCRIBING LAND RECTENNA  
LOCATIONS IN EACH STATE\***

| Location No.       | Counties Impacted                       |                                            |                              |          | Transportation     |          |           |                     | Utility Ties Distance (~ miles) | Comments                                                                                                         |
|--------------------|-----------------------------------------|--------------------------------------------|------------------------------|----------|--------------------|----------|-----------|---------------------|---------------------------------|------------------------------------------------------------------------------------------------------------------|
|                    | Name                                    | Persons/<br>Square Mile                    | Elevation<br>Characteristics | Land Use | Roads              |          | Railroads | River               |                                 |                                                                                                                  |
|                    |                                         |                                            |                              |          | Type               | Miles    |           |                     |                                 |                                                                                                                  |
| <u>ALABAMA</u>     |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| 3                  | Lawrence<br>Winston<br>Franklin         | 25 to 49.9<br>10 to 24.9<br>10 to 24.9     | C3c                          | 6, 3     | State 33<br>County | 10<br>20 | No        | Creeks              | 10                              | Partially located in Bankhead Forest; escarpments and valley sides                                               |
| <u>ALASKA</u>      |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| <u>ARIZONA</u>     |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| 1                  | Maricopa                                | 50 to 99.9                                 | B5a                          | 10       | No                 | 0        | No        | Creek               | 60                              | Same county as Phoenix.<br>Not on reservation                                                                    |
| 2                  | Apache                                  | <5                                         | B2c, B4c                     | 8, 9     | No                 | 0        | No        | Creek               | 30                              |                                                                                                                  |
| <u>ARKANSAS</u>    |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| 1                  | Clark                                   | 10 to 24.9                                 | B2b, C4a                     | 3, 6     | State 26, 8        | 25       | No        | Creek               | 10                              | Over one town<br>Over Ouachita National Forest;<br>Saline, next to Little Rock;<br>over two towns.               |
| 2                  | Saline<br>Perry                         | 25 to 49.9<br>5 to 9.9                     | C5a<br>C4a                   | 6        | State 7<br>County  | 5<br>15  | No        | Creeks and<br>lakes | 25                              |                                                                                                                  |
| <u>CALIFORNIA</u>  |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| 4                  | San Bernardino                          | 25 to 50                                   | A3a                          | 11, 10   | 2 County<br>No     | 25       | No        | No                  | 15                              | Not actually near Los Angeles                                                                                    |
| 3                  | San Bernardino                          | 250 or more<br>25 to 50                    | B5a                          | 11, 10   |                    | —        | No        | No                  | 10                              | Crests                                                                                                           |
| <u>COLORADO</u>    |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| 1                  | El Paso<br>Pueblo<br>Lincoln<br>Crowley | 50 to 99.9<br>25 to 49.9<br><5<br>5 to 9.9 | B3c                          | 8, 2     | County             | 15       | No        | No                  | 5                               | El Paso county contains Colorado Springs; Pueblo county contains Pueblo; rectenna is not adjacent to either city |
| 2                  | Yuma                                    | <5                                         | B2c, A2c                     | 1, 2, 8  | 2 County           | 30       | No        | No                  | 10                              |                                                                                                                  |
| <u>CONNECTICUT</u> |                                         |                                            |                              |          |                    |          |           |                     |                                 |                                                                                                                  |
| None Identified    |                                         |                                            |                              |          |                    |          |           |                     |                                 | Consider over Atlantic Ocean                                                                                     |

\*Elevations characteristics and land usage keys on pages 77 and 78.

TABLE A-1. (Continued)

| Location No.    | Counties Impacted    |                          |                           |           | Transportation         |       |           |        | Utility Ties Distance (~miles) | Comments                                                                              |
|-----------------|----------------------|--------------------------|---------------------------|-----------|------------------------|-------|-----------|--------|--------------------------------|---------------------------------------------------------------------------------------|
|                 | Name                 | Persons Square Mile      | Elevation Characteristics | Land Use  | Roads                  |       | Railroads | River  |                                |                                                                                       |
|                 |                      |                          |                           |           | Type                   | Miles |           |        |                                |                                                                                       |
| None Identified |                      |                          |                           |           | <u>DELAWARE</u>        |       |           |        |                                | Consider over Atlantic Ocean                                                          |
|                 |                      |                          |                           |           | <u>FLORIDA</u>         |       |           |        |                                |                                                                                       |
| 1               | Collier              | 5 to 9.9                 | A1                        | 13, 6, 14 | No                     | —     | No        | No     | 50                             | Everglades swamplands — >50 percent area covered by standing water                    |
| 2               | Liberty Franklin     | <5<br>10 to 24.9         | A1                        | 6, 13     | Small State and County | 20    | No        | No     | 0                              | Appalachicola National Forest — >50 percent area covered by standing water            |
|                 |                      |                          |                           |           | <u>GEORGIA</u>         |       |           |        |                                |                                                                                       |
| 3               | Ware Charlton        | 25 to 49.9<br>5 to 9.9   | A1                        | 13, 6     | No                     | —     | No        | Small  | 30                             | Okefenokee Swamp and National Wildlife Refuge — >50 percent covered by standing water |
|                 |                      |                          |                           |           | <u>HAWAII</u>          |       |           |        |                                |                                                                                       |
| None Identified |                      |                          |                           |           | <u>IDAHO</u>           |       |           |        |                                | Consider over Pacific Ocean                                                           |
| 1               | Jefferson Bonneville | 10 to 24.9<br>25 to 49.9 | B3b                       | 10, 4     | No                     | —     | No        | No     | 0                              | Bonneville County contains Idaho Falls                                                |
| 2               | Blaine Minidoka      | <5<br>10 to 24.9         | B3b                       | 10        | No                     | —     | No        | No     | 35                             |                                                                                       |
|                 |                      |                          |                           |           | <u>ILLINOIS</u>        |       |           |        |                                |                                                                                       |
| None Identified |                      |                          |                           |           | <u>INDIANA</u>         |       |           |        |                                | Consider over Lake Michigan                                                           |
| None Identified |                      |                          |                           |           | <u>IOWA</u>            |       |           |        |                                | Consider over Lake Michigan                                                           |
| 1               | Plymouth             | 25 to 49.9               | A2b, B2c                  | 1         | County                 | 45    | No        | Creeks | 20                             |                                                                                       |

TABLE A-1. (Continued)

| Location No.         | Counties Impacted                         |                                                  |                              |          | Transportation     |       |           |                       | Utility Ties Distance (~ miles) | Comments                                                                                |
|----------------------|-------------------------------------------|--------------------------------------------------|------------------------------|----------|--------------------|-------|-----------|-----------------------|---------------------------------|-----------------------------------------------------------------------------------------|
|                      | Name                                      | Persons/<br>Square Mile                          | Elevation<br>Characteristics | Land Use | Roads              |       | Railroads | River                 |                                 |                                                                                         |
|                      |                                           |                                                  |                              |          | Type               | Miles |           |                       |                                 |                                                                                         |
| <u>KANSAS</u>        |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| 1                    | Greeley<br>Hamilton<br>Wichita<br>Kearny  | <5<br><5<br><5<br><5                             | A2c                          | 1        | County             | 45    | No        | No                    | 20                              | Site could be moved north so rectennas would not be so close together                   |
| 2                    | Haskell<br>Finney<br>Grant<br>Kearny      | 5 to 9.9<br>10 to 24.9<br>5 to 9.9<br><5         | A2c                          | 1        | County             | 35    | No        | No                    | 20                              | >50 percent of area covered by sand                                                     |
| <u>KENTUCKY</u>      |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| <u>LOUISIANA</u>     |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| 1                    | Cameron                                   | <5                                               | A1                           | 14       | No                 | —     | No        | Creeks                | 20                              | Sabine National Wildlife Reserve — >50 percent land covered by standing water           |
| 2                    | Tensas<br>Franklin                        | 10 to 24.9<br>25 to 49.9                         | A1                           | 13, 3    | Small<br>State 573 | 15    | No        | Tensas River<br>Bayou | 20                              | 10 to 50 percent covered by standing water                                              |
| <u>MAINE</u>         |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| 1                    | Somerset                                  | 10 to 24.9                                       | C4a                          | 7        | No                 | —     | No        | Creeks and<br>ponds   | 40                              |                                                                                         |
| 2                    | Aroostook                                 | 10 to 24.9                                       | C4a                          | 7        | No                 | —     | No        | Creek                 | 80                              |                                                                                         |
| <u>MARYLAND</u>      |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| None Identified      |                                           |                                                  |                              |          |                    |       |           |                       |                                 | Consider over Atlantic Ocean                                                            |
| <u>MASSACHUSETTS</u> |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| None Identified      |                                           |                                                  |                              |          |                    |       |           |                       |                                 | Consider over Atlantic Ocean                                                            |
| <u>MICHIGAN</u>      |                                           |                                                  |                              |          |                    |       |           |                       |                                 |                                                                                         |
| 1                    | Iron<br>Baraga<br>Marquette               | 10 to 24.9<br>5 to 9.9<br>25 to 49.9             | B2b                          | 7        | No                 | —     | No        | Small                 | 30                              | 10 to 50 percent of area covered by standing water                                      |
| 2                    | Oscoda<br>Ogemaw<br>Roscommon<br>Crawford | 5 to 9.9<br>10 to 24.9<br>10 to 24.9<br>5 to 9.9 | A2b, B2b                     | 7, 5     | County             | 40    | No        | Small                 | 20                              | Partially in Huron National Forest — 10 to 50 percent of area covered by standing water |

TABLE A-1. (Continued)

| Location No.       | Counties Impacted |                         |                              |             | Transportation |       |           |        | Utility Ties Distance (~miles) | Comments                                                                                                     |
|--------------------|-------------------|-------------------------|------------------------------|-------------|----------------|-------|-----------|--------|--------------------------------|--------------------------------------------------------------------------------------------------------------|
|                    | Name              | Persons/<br>Square Mile | Elevation<br>Characteristics | Land Use    | Roads          |       | Railroads | River  |                                |                                                                                                              |
|                    |                   |                         |                              |             | Type           | Miles |           |        |                                |                                                                                                              |
| <u>MINNESOTA</u>   |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 1                  | Beltrami          | 5 to 9.9                | A1                           | 13, 5, 14   | No             | —     | No        | No     | 40                             | 10 to 50 percent of land covered by standing water<br>>50 percent of area covered by standing water          |
| 2                  | Koochiching       | 5 to 9.9                | A1                           | 14          | County         | 10    | No        | Creeks | 70                             |                                                                                                              |
| <u>MISSISSIPPI</u> |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 1                  | Wayne             | 10 to 24.9              | B2b                          | 6, 13, 5    | Small State    | 30    | No        | Creeks | 10                             | De Soto National Forest —<br>Jones County contains Laurel<br>Partially over Noxubee National Wildlife Refuge |
| 3                  | Jones             | 50 to 99.9              | B2b                          | 2, 3        | and County     | 20    | No        | Creeks | 25                             |                                                                                                              |
|                    | Oktibbeha         | 50 to 99.9              |                              | Small State |                |       |           |        |                                |                                                                                                              |
|                    | Winston           | 25 to 49.9              |                              | and County  |                |       |           |        |                                |                                                                                                              |
|                    | Noxubee           | 10 to 24.9              |                              |             |                |       |           |        |                                |                                                                                                              |
| <u>MISSOURI</u>    |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 2                  | Monroe            | 10 to 24.9              | A2d                          | 1, 3        | State 15       | 15    | No        | Creeks | 40                             | Over two towns                                                                                               |
| 3                  | Audrain           | 25 to 49.9              | C3c, A1                      | 6, 3        | County         | 25    | No        | Small  | 45                             |                                                                                                              |
|                    | Oregon            | 10 to 24.9              |                              |             | County         | 40    |           |        |                                |                                                                                                              |
|                    | Carter            | 5 to 9.9                |                              |             |                |       |           |        |                                |                                                                                                              |
|                    | Ripley            | 10 to 24.9              |                              |             |                |       |           |        |                                |                                                                                                              |
|                    | Shannon           | 5 to 9.9                |                              |             |                |       |           |        |                                | Mark Twain National Forest —<br>over three towns                                                             |
| <u>MONTANA</u>     |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 1                  | McCone            | <5                      | B3c, C4c                     | 8, 2        | County         | 15    | No        | No     | 25                             | Crests                                                                                                       |
| 2                  | Garfield          | <5                      | B3c, C4c                     | 8           | No             | —     | No        | Creek  | 50                             | Crests                                                                                                       |
|                    | Rosebud           | <5                      |                              |             |                |       |           |        |                                |                                                                                                              |
| <u>NEBRASKA</u>    |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 1                  | Garden            | <5                      | C3c                          | 8           | No             | —     | No        | No     | 30                             | Lakes in area; near National Wildlife<br>Refuge — >50 percent covered by sand<br>>50 percent covered by sand |
| 2                  | Cherry            | <5                      | C3c                          | 8           | County         | 30    | No        | No     | 60                             |                                                                                                              |
| <u>NEVADA</u>      |                   |                         |                              |             |                |       |           |        |                                |                                                                                                              |
| 3                  | Nye               | <5                      | B5a                          | 10          | No             | —     | No        | No     | 90                             | Desert valley — crests                                                                                       |
|                    | Humboldt          | <5                      | B5a                          | 10          | No             | —     | No        | No     | 15                             | Near Indian Reservation — crests                                                                             |

ORIGINAL PAGE IS  
OF POOR QUALITY

TABLE A-1. (Continued)

| Location No.          | Counties Impacted     |                            |                           |          | Transportation      |          |           |                                    | Utility Ties Distance (~miles) | Comments                                                     |
|-----------------------|-----------------------|----------------------------|---------------------------|----------|---------------------|----------|-----------|------------------------------------|--------------------------------|--------------------------------------------------------------|
|                       | Name                  | Persons/<br>Square Mile    | Elevation Characteristics | Land Use | Roads               |          | Railroads | River                              |                                |                                                              |
|                       |                       |                            |                           |          | Type                | Miles    |           |                                    |                                |                                                              |
| <u>NEW HAMPSHIRE</u>  |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 1                     | Coos                  | 10 to 24.9                 | C5a                       | 7        | County              | 5        | No        | Several Streams<br>Several Streams | 30                             | Crests                                                       |
| 2                     | Grafton<br>Carroll    | 25 to 49.9<br>10 to 24.9   | D5                        | 7,5      | State and<br>County | 20<br>15 | No        |                                    | 15                             | White Mountain National Forest —<br>crests; covers two towns |
| <u>NEW JERSEY</u>     |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| <u>NEW MEXICO</u>     |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 1                     | Chaves                | 5 to 9.9                   | A2b                       | 10,8     | No                  | —        | No        | No                                 | 30                             | Consider over Atlantic Ocean                                 |
| 2                     | Harding               | <5                         | B3c                       | 8,9      | No                  | —        | No        | No                                 | 90                             |                                                              |
| <u>NEW YORK</u>       |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 1                     | St. Lawrence          | 25 to 49.9                 | B4b                       | 7        | Small State         | 5        | No        | Several small<br>creeks            | 5                              | Adirondack Forest Reserve<br>Crests                          |
| 3                     | Hamilton<br>Herkimer  | <5<br>25 to 49.9           | C5a                       | 7        | No                  | —        | No        |                                    | 40                             |                                                              |
| <u>NORTH CAROLINA</u> |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 1                     | Pasquotank<br>Gates   | 100 to 249.9<br>25 to 49.9 | A1                        | 3,13,5   | US 158              | 15       | No        | No                                 | 5                              | >50 percent of land covered by<br>standing water             |
| 2                     | Perquimans<br>Tyrrell | 25 to 49.9<br>10 to 24.9   | A1                        | 13       | State 94            | 15       | No        | No                                 | 50                             | >50 percent of land covered by<br>standing water             |
| <u>NORTH DAKOTA</u>   |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 1                     | Ward                  | 10 to 24.9                 | B2b, A2c                  | 1,8      | State 23            | 15       | No        | No                                 | 30                             | Consider over Lake Erie                                      |
| 2                     | Stutsman              | 10 to 24.9                 | B2b, A2c                  | 1        | County              | 20       | No        | No                                 | 25                             |                                                              |
|                       |                       |                            |                           |          | County              | 30       |           |                                    |                                |                                                              |
| <u>OHIO</u>           |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| <u>OKLAHOMA</u>       |                       |                            |                           |          |                     |          |           |                                    |                                |                                                              |
| 3                     | Cimarron              | <5                         | A2c                       | 8        | County              | 20       | No        | Small                              | 75                             | >50 percent of area covered by sand                          |
| 4                     | Woodward<br>Ellis     | 10 to 24.9<br><5           | B2b, B3c                  | 1        | County              | 35       | No        | No                                 | 15                             |                                                              |

TABLE A-1. (Continued)

| Location No.          | Counties Impacted |                         |                           |          | Transportation |       |           |                        | Utility Ties Distance (~miles) | Comments                                                                      |
|-----------------------|-------------------|-------------------------|---------------------------|----------|----------------|-------|-----------|------------------------|--------------------------------|-------------------------------------------------------------------------------|
|                       | Name              | Persons/<br>Square Mile | Elevation Characteristics | Land Use | Roads          |       | Railroads | River                  |                                |                                                                               |
|                       |                   |                         |                           |          | Type           | Miles |           |                        |                                |                                                                               |
| <u>OREGON</u>         |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| 1                     | Lake              | <5                      | B4b, B5b                  | 10       | —              | —     | —         | —                      | 0                              |                                                                               |
| 2                     | Malheur           | <5                      | B4c                       | 10       | —              | —     | —         | Creek                  | 35                             |                                                                               |
| <u>PENNSYLVANIA</u>   |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| 2                     | Warren Forest     | 50 to 99.9              | C4d                       | 7        | State 666      | 15    | —         | Tionesta               | 0                              | Allegheny National Forest —<br>over two towns<br>Escarpments and valley sides |
| 3                     | Clearfield        | 10 to 24.9              | C4d, D5                   | 7        | County         | 25    | No        | Creek                  | 0                              |                                                                               |
|                       | Cameron           | 50 to 99.9              |                           |          | No             | No    |           |                        |                                |                                                                               |
|                       | Elk               | 10 to 24.9              |                           |          |                |       |           |                        |                                |                                                                               |
| <u>RHODE ISLAND</u>   |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| None Identified       |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| <u>SOUTH CAROLINA</u> |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| 1                     | Kershaw           | 25 to 49.9              | B2c                       | 3, 5, 6  | State 5        | 50    | —         | Lynches                | 15                             | Slightly over Carolina Sand<br>Hills National Wildlife Refuge                 |
|                       | Chesterfield      | 25 to 49.9              |                           |          |                |       |           |                        |                                |                                                                               |
|                       | Lancaster         | 50 to 99.9              |                           |          |                |       |           |                        |                                |                                                                               |
| <u>SOUTH DAKOTA</u>   |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| 1                     | Sully             | <5                      | A2c                       | 2        | Small State    | 20    | —         | Creek                  | 45                             |                                                                               |
| 2                     | Hyde              | <5                      | A2c, B2b                  | 1, 2, 3  | and County     | 25    | —         | Several small<br>lakes | 35                             |                                                                               |
|                       | 2                 | McPherson               |                           |          | 5 to 9.9       |       |           |                        |                                |                                                                               |
| <u>TENNESSEE</u>      |                   |                         |                           |          |                |       |           |                        |                                |                                                                               |
| 3                     | Cumberland        | 25 to 49.9              | C3a                       | 6, 3     | State 101      | 15    | No        | Small creeks           | 0                              | Over three small towns                                                        |
|                       | Bledsoe           | 10 to 24.9              | C5c                       |          |                |       |           |                        |                                |                                                                               |
|                       | Van Buren         | 10 to 24.9              |                           |          |                |       |           |                        |                                |                                                                               |
|                       | White             | 25 to 49.9              |                           |          |                |       |           |                        |                                |                                                                               |
| 1                     | Hardin            | 25 to 49.9              | C3b                       | 3, 5, 6  | State 69       | 15    | —         | Horse Creek            | 10                             |                                                                               |
|                       | Wayne             | 10 to 24.9              |                           |          | County         | 20    |           |                        |                                |                                                                               |

ORIGINAL PAGE IS  
OF POOR QUALITY

TABLE A-1. (Concluded)

| Location No.         | Counties Impacted                     |                                        |                           |          | Transportation      |         |           |                        | Utility Ties Distance (~ miles) | Comments                                          |
|----------------------|---------------------------------------|----------------------------------------|---------------------------|----------|---------------------|---------|-----------|------------------------|---------------------------------|---------------------------------------------------|
|                      | Name                                  | Person/<br>Square Mile                 | Elevation Characteristics | Land Use | Roads               |         | Railroads | River                  |                                 |                                                   |
|                      |                                       |                                        |                           |          | Type                | Miles   |           |                        |                                 |                                                   |
| <u>TEXAS</u>         |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Andrews                               | 5 to 9.9                               | A2c                       | 8        | —                   | —       | —         | —                      | 20                              |                                                   |
| 3                    | Webb                                  | 10 to 24.9                             | B2b                       | 10       | —                   | —       | —         | No                     | 30                              |                                                   |
| <u>UTAH</u>          |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Tooele                                | <5                                     | A2a                       | 10,11    | —                   | —       | —         | —                      | 40                              | In Great Salt Lake Desert                         |
| 2                    | Tooele                                | <5                                     | A2a                       | 11       | —                   | —       | —         | —                      | 80                              |                                                   |
| <u>VERMONT</u>       |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Essex                                 | 5 to 9.9                               | C5a                       | 7        | —                   | —       | —         | Small lakes and creeks | 30                              |                                                   |
| <u>VIRGINIA</u>      |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Amelia<br>Cumberland<br>Prince Edward | 10 to 24.9<br>10 to 24.9<br>25 to 49.9 | B2c                       | 3, 5, 7  | County<br>State 307 | 50<br>2 | —         | Appomattox River       | 15                              | Over two towns                                    |
| <u>WASHINGTON</u>    |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Grays Harbor                          | 25 to 49.9                             | C3b                       | 7        | —                   | —       | —         | Several small rivers   | 15                              | Borders Olympic National Forest — covers one town |
| 2                    | Lincoln                               | <5                                     | B3c                       | 1,8      | County              | 50      | —         | Small lakes            | 15                              |                                                   |
| <u>WEST VIRGINIA</u> |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Pocahontas<br>Webster                 | 10 to 24.9<br>10 to 24.9               | C5d<br>D5                 | 3, 5, 7  | County              | 20      | —         | Cranberry River        | 20                              | Over Monogahela National Forest                   |
| <u>WISCONSIN</u>     |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Douglas                               | 25 to 49.9                             | A2c, B4c                  | 5, 7     | County              | 25      | —         | Creeks                 | 20                              | In Chequamegon National Forest                    |
| 2                    | Bayfield                              | 5 to 9.9                               | A2c, B4c                  | 5, 7     | County              | 15      | —         | Creeks                 | 15                              |                                                   |
| <u>WYOMING</u>       |                                       |                                        |                           |          |                     |         |           |                        |                                 |                                                   |
| 1                    | Sweetwater                            | <5                                     | B3b                       | 10       | —                   | —       | —         | No                     | 15                              |                                                   |
| 2                    | Converse                              | <5                                     | B3c                       | 8        | County              | 10      | —         | Creeks                 | 10                              |                                                   |

TABLE A-2. ELEVATIONS CHARACTERISTICS KEY

Classes of Land Surface Form

Plains

- A1 — Flat plains
- A2 — Smooth plains
- B1 — Irregular plains, slight relief
- B2 — Irregular plains

Tablelands

- B3c,d — Tablelands, moderate relief
- B4c,d — Tablelands, considerable relief
- B4c,d — Tablelands, high relief
- B6c,d — Tablelands, very high relief

Plains with Hills or Mountains

- A, B3a, b — Plains with hills
- B4a, b — Plains with high hills
- B5a, b — Plains with low mountains
- B6a, b — Plains with high mountains

Open Hills and Mountains

- C2 — Open low hills
- C3 — Open hills
- C4 — Open high hills
- C5 — Open low mountains
- C6 — Open high mountains

Hills and Mountains

- D3 — Hills
- D4 — High hills
- D5 — Low mountains
- D6 — High mountains

Scheme of Classification

Slope (Capital Letters)

- A — More than 80 percent of area gently sloping
- B — 50 to 80 percent of area gently sloping
- C — 20 to 50 percent of area gently sloping
- D — Less than 20 percent of area gently sloping

Local Relief (Number)

- 1 — 0 to 100 ft
- 2 — 100 to 300 ft
- 3 — 300 to 500 ft
- 4 — 500 to 1000 ft
- 5 — 1000 to 3000 ft
- 6 — Over 3000 ft

Profile Type

- a — More than 75 percent of gently slope in lowland
- b — 50 to 75 percent of gentle slope in lowland
- c — 50 to 75 percent of gently slope in upland
- d — More than 75 percent of gently slope in upland

Other Classes (Noted in Work Sheet Comments)

- Greater than 50 percent of area covered by sand
- 10 to 50 percent of area covered by standing water
- Greater than 50 percent of area covered by standing water
- Irregular peaks and cones
- Crests
- Escarments and valley sides



TABLE A-3. LAND USAGE KEY

|    |                                                    |
|----|----------------------------------------------------|
| 1  | Mostly cropland                                    |
| 2  | Cropland and grazing land                          |
| 3  | Cropland with pasture, woodland, and forest        |
| 4  | Irrigated land                                     |
| 5  | Woodland and forest with some cropland and pasture |
| 6  | Forest and woodland; grazed                        |
| 7  | Forest and woodland; mostly ungrazed               |
| 8  | Subhumid grassland and semiarid grazing land       |
| 9  | Open woodland; grazed                              |
| 10 | Desert shrubland; grazed                           |
| 11 | Desert shrubland; mostly ungrazed                  |
| 12 | Alpine meadows, mountain peaks above timberline    |
| 13 | Swamp                                              |
| 14 | Marshland                                          |
| 15 | Moist tundra and muskeg                            |

TABLE A-4. LOCATIONS OF RECTENNAS IN THE PACIFIC

| Location No. | Coordinates         | Depth Range  | Comments                                           |
|--------------|---------------------|--------------|----------------------------------------------------|
|              | <u>WASHINGTON</u>   |              |                                                    |
| 1s           | 124°40' W, 47°15' N | 186' to 348' | More sites could be located in "Warning Area"      |
| 2s           | 124°25' W, 46°50' N | 186' to 342' | Located in a "Warning Area"                        |
|              |                     |              | Partially located in a "Restricted Dumping Ground" |
|              | <u>OREGON</u>       |              |                                                    |
| 1s           | 124°10' W, 46°05' N | 198' to 360' |                                                    |
| 2s           | 124°10' W, 44°25' N | 72' to 240'  |                                                    |
| 3s           | 124°15' W, 44°10' N | 78' to 324'  |                                                    |
| 4s           | 124°30' W, 42°35' N | 96' to 366'  |                                                    |
|              | <u>CALIFORNIA</u>   |              |                                                    |
| 1s           | 124°15' W, 42°N     | 66' to 312'  |                                                    |
| 2s           | 124°15' W, 41°40' N | 66' to 294'  |                                                    |
| 3s           | 124°15' W, 41°20' N | 72' to 372'  |                                                    |
| 6s           | 123°15' W, 38°15' N | 252' to 402' |                                                    |
| 7s           | 122°30' W, 37°10' N | 78' to 390'  |                                                    |
| 8s           | 120°45' W, 35°05' N | 66' to 552'  |                                                    |
| 9s           | 119°35' W, 35°15' N | 90' to 534'  | Covers a "Caution Area"                            |

ORIGINAL PAGE IS  
OF POOR QUALITY

TABLE A-5. LOCATIONS OF RECTENNAS IN THE NORTH ATLANTIC

| Location No. | Coordinates          | Depth Range  | Comments                       |
|--------------|----------------------|--------------|--------------------------------|
|              | <u>MAINE</u>         |              |                                |
| 1s           | 70°25' W, 43°15' N   | 72' to 240'  | Southern tip of Maine          |
|              | <u>MASSACHUSETTS</u> |              |                                |
| 1s           | 70°25' W, 42°40' N   | 114' to 258' |                                |
| 2s           | 70°10' W, 42°25' N   | 156' to 294' |                                |
| 3s           | 70°25' W, 42°05' N   | 126' to 198' |                                |
| 4s           | 70°10' W, 41°N       | 72' to 108'  |                                |
| 5s           | 70°45' W, 41°10' N   | 93' to 144'  |                                |
|              | <u>NEW YORK</u>      |              |                                |
| 1s           | 72°W, 40°50' N       | 72' to 132'  |                                |
| 2s           | 72°35' W, 40°40' N   | 78' to 126'  |                                |
|              | <u>NEW JERSEY</u>    |              |                                |
| 1s           | 74°20' W, 39°05' N   | 48' to 96'   | Over a "Danger Area"           |
| 2s           | 74°W, 39°30' N       | 66' to 84'   |                                |
|              | <u>DELAWARE</u>      |              |                                |
| 1s           | 74°45' W, 38°45' N   | 30' to 102'  | Between main shipping channels |
|              | <u>MARYLAND</u>      |              |                                |
| 1s           | 74°45' W, 38°15' N   |              |                                |

TABLE A-6. LOCATIONS OF RECTENNAS IN THE SOUTH ATLANTIC

| Location No. | Coordinates           | Depth Range | Comments                                                                                                                        |
|--------------|-----------------------|-------------|---------------------------------------------------------------------------------------------------------------------------------|
|              | <u>VIRGINIA</u>       |             |                                                                                                                                 |
| 1s           | 75°W, 37°55' N        | 60' to 108' | One alternate location also identified in Virginia                                                                              |
| 2s           | 75°15' W, 37°25' N    | 60' to 102' |                                                                                                                                 |
|              | <u>NORTH CAROLINA</u> |             |                                                                                                                                 |
| 3s           | 75°10' W, 35°25' N    | 54' to 102' | Two alternate sites also identified in North Carolina<br>Could be moved to a "Danger Area"<br>Could be moved to a "Danger Area" |
| 4s           | 75°55' W, 34°55' N    | 66' to 84'  |                                                                                                                                 |
| 5s           | 76° 50' W, 34°25' N   | 66' to 90'  |                                                                                                                                 |
| 6s           | 77°25' W, 34°05' N    | 66' to 96'  |                                                                                                                                 |
|              | <u>SOUTH CAROLINA</u> |             |                                                                                                                                 |
| 1s           | 78°20' W, 33°30' N    | 66' to 78'  | Could be moved to a "Prohibited Dumping Area"<br>Could be moved to a "Dumping Ground"                                           |
| 2s           | 79°W, 32°50' N        | 66' to 84'  |                                                                                                                                 |
| 3s           | 80°10' W, 32°15' N    | 42' to 66'  |                                                                                                                                 |
|              | <u>GEORGIA</u>        |             |                                                                                                                                 |
| 1s           | 80°50' W, 31°30' N    | 48' to 66'  | Could be moved to a "Danger Area"<br>Partially off Florida coast                                                                |
| 2s           | 81°W, 30°40' N        | 48' to 66'  |                                                                                                                                 |

TABLE A-7. LOCATIONS OF RECTENNAS IN THE GULF OF MEXICO

| Location No. | Coordinates        | Depth Range | Comments                                                                                                                                      |
|--------------|--------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
|              | <u>FLORIDA</u>     |             |                                                                                                                                               |
| 1s           | 87°05' W, 30°05' N | 72' to 126' | All Florida sea rectennas located in Gulf to avoid impact by space program launch activity from Cape Canaveral and because water is shallower |
| 2s           | 83°40' W, 29°30' N | 33' to 54'  |                                                                                                                                               |
| 3s           | 83°10' W, 28°15' N | 33' to 66'  |                                                                                                                                               |
| 4s           | 82°50' W, 27°05' N | 66' to 96'  |                                                                                                                                               |
| 5s           | 82°25' W, 26°10' N | 63' to 84'  |                                                                                                                                               |
|              | <u>MISSISSIPPI</u> |             |                                                                                                                                               |
| 1s           | 88°30' W, 30°N     | 66' to 96'  |                                                                                                                                               |
|              | <u>LOUISIANA</u>   |             |                                                                                                                                               |
| 1s           | 93°20' W, 29°N     | 63' to 78'  |                                                                                                                                               |
| 2s           | 92°40' W, 29°10' N | 66' to 84'  |                                                                                                                                               |
| 3s           | 89°50' W, 29°N     | 66' to 138' |                                                                                                                                               |
| 4s           | 90°15' W, 28°50' N | 66' to 96'  |                                                                                                                                               |
|              | <u>TEXAS</u>       |             |                                                                                                                                               |
| 1s           | 94°05' W, 28°50' N | 66' to 84'  |                                                                                                                                               |
| 2s           | 94°50' W, 28°50' N | 63' to 90'  |                                                                                                                                               |
| 3s           | 95°45' W, 28°20' N | 84' to 126' |                                                                                                                                               |
| 4s           | 97°05' W, 27°25' N | 66' to 102' |                                                                                                                                               |
| 5s           | 97°10' W, 26°50' N | 66' to 114' |                                                                                                                                               |

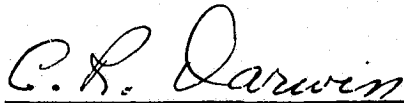
# APPROVAL

## CANDIDATE LOCATIONS FOR SPS RECTIFYING ANTENNAS

By Anne W. Eberhardt

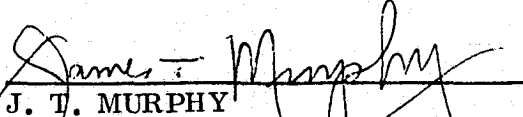
The information in this report has been reviewed for security classification. Review of any information concerning Department of Defense or Atomic Energy programs or activities has been made by the MSFC Security Classification Officer. This report, in its entirety, has been determined to be unclassified.

This document has also been reviewed and approved for technical accuracy.



C. R. DARWIN

Director, Preliminary Design Office



J. T. MURPHY

Director, Program Development